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ABSTRACT

Presented is the Home Economics component of the Iowa Developed Energy Activity Sampler (IDEAS), a multidisciplinary energy education program designed for infusion into the curriculum of grades 7-12. Also included in the program are activity sets for Industrial Arts (SE 034 679), Language Arts (SE 034 680), Mathematics (SE 034 681), Science (SE 034 682), and Social Studies (SE 034 683). Contained in this manual are the 43 student-centered activities from the complete IDEAS curriculum that relate to secondary home economics. Activities are arranged under six concepts: (1) Energy is basic; (2) Energy usefulness is limited; (3) The environment is affected by energy exchanges; (4) Energy choices affect society; (5) Conservation; and (6) The future is ours to shape and share. Among the topics covered are calorie measurement, energy efficiency, energy costs, insulation, and meter reading. Activities are illustrated by drawings, charts, or diagrams and include background information and discussion questions. (Author/WB)

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I. D. E. A. S.
for
Home Economics

SE 034 678

Iowa Developed Energy Activity Sampler

Sponsored by:

Iowa Energy Policy Council
in cooperation with
Iowa Department of Public Instruction

1980

Iowa Developed Energy Activity Sampler Grades 7-12

1980

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This notebook is one of a series of six notebooks which include the subject matter areas of home economics, industrial arts, language arts, mathematics, science, and social sciences.

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Education and Energy

Background:

We live in a sea of energy, a balance of delicate and powerful forces that are so much a part of daily experience that their rhythm is often ignored. Life itself is energy conversion--intimate, dynamic, natural, precious, and taken-for-granted. Energy? We live it, use it, give it, and are suddenly surprised to discover that it is related to

—high prices;
—short supplies of basic goods and services;
—lack of national self-sufficiency;
—industrial, technological, educational systems;
—time and materials use;
—mobility, lifestyles, environmental problems, future options;
—quantity and quality of life.

Definition of the Problem:

Modern industry, agriculture, and transportation systems make possible a standard of living that is dependent upon cheap, easily transportable energy sources. Use of inherited energy capital (fossil fuels) for expanded industrial and agricultural production has supported a population that is now far larger than that which existed throughout the world's previous history, and the population is still growing. Moreover, individuals are using increasing amounts of fossil fuels as they acquire more manufactured articles and adopt energy-intensive lifestyles.

Strategy:

The framework used in developing the following activities is the "infusion" model. Recognizing that various aspects of energy education fit well into existing disciplines--especially (but not exclusively) the sciences, social sciences, home economics, mathematics, industrial arts, and language arts--the Iowa Energy Policy Council and the Energy Education Advisory Committee hope that individual teachers will choose activities that complement and extend the topics usually covered or the skills to be developed and strengthened in their classes.

Some suggestions may stimulate cooperative multidisciplinary or interdisciplinary activities as well. Energy education is interdisciplinary because every area of human endeavor depends on energy. The emphasis on energy as a basic consideration for every aspect of life will put a new perspective on much human knowledge and show a "connectedness" that was not obvious before. Energy choices are not only technological ones; they are likely to have multivariate effects on personal and international economics, the environment, and its capacity to safely sustain us, the materials our children may hope to use, and the lifestyle options that future generations may have.

A variety of approaches is recommended for teaching about energy. The activities included are just a few examples of the ways to stimulate an energy awareness, new perspectives on the interdependencies of people and other living things, and recognition of human value/choice/action synergies that will shape the future. Teachers and students can demonstrate, experiment, build, discuss, debate, survey, role-play, write, draw, research, explore, brainstorm, consider alternatives and consequences, model, investigate, measure, calculate, dramatize, and display progress in understanding energy and in practicing less wasteful energy use.

Energy flows in all directions throughout the physical world, but some of it comes to a focus in the biosphere and in the flowering of human culture. It seems natural that energy awareness should also grow by a gathering of illuminations from various sources, both practical and theoretical, and should involve many skills. Ideally, energy education will foster curricular integration, will help develop a conservation ethic, and will challenge the inventiveness and initiative of creative minds.

Summary of Energy Education Concepts

1. Energy is basic.

Energy exists in various forms and states.
Energy flows, transfers itself.
Life itself is energy conversion, a series of interactions with the physical world.
Humankind measures energy in various ways.

2. Energy usefulness is limited.

Laws of thermodynnamics describe physical constraints.
Natural resources are limited in amount and in usefulness. They require energy to extract, so "net yield" accounting is necessary for future developments.
Exponential rate of using cannot continue.
Economics dictate some restrictions.

3. Environment is affected by energy exchanges.

Mined (fossil) energy measurably disrupts natural systems during
a. extraction
b. transportation and distribution
c. consumption (including electrical generation).
Capturing solar and wind energies may require new materials, non-traditional land allocations, and population shifts with unknown side-effects on global environment.
All other energy alternatives also will cause varying degrees of environmental change.

4. Energy choices affect society.

Energy is the true basis of economics.
Lifestyles vary with energy use.
Employment patterns vary with energy availability.
Life, health, and literacy have been correlated to energy consumption.
International relations and trade are directly influenced by energy distribution.
World inequities in energy supplies suggest future challenges and priorities.

5. The case for conservation.

There is a need to conserve and "buy time" for a more gradual energy transition and development of alternatives.
The relative importance of energy-using activities must be considered:
   a. actual needs
   b. perceived needs
   c. non-essential uses
Ways to reduce energy consumption must be explained and demonstrated.

6. The future is ours to shape and share.

Time-sense must be developed, the present in relation to past and to projections for the future:
   a. mid-term of "one generation" or ∽ 30 years.
   b. long-term alternatives and possibilities.
Dreams for the future are the only realizable ones. Without them we act blindly.

"Quality of life" may be redefined.

Teaching the Energy Lesson

The activities included in this publication are not a special step-by-step "course." Rather, they are suggestions to get interested teachers started on the process of incorporating energy concepts into existing classes.

The concepts represented by particular articles and activities include those outlined under Summary of Energy Education Concepts. Briefly, they are that:

1. Energy is basic.
2. Energy usefulness is limited.
3. Environment is affected by energy exchanges.
4. Energy choice affects society.
5. Conservation is essential.
6. The future is shaped by today's decisions.

Some of the activities are teacher-directed or demonstrated. Others are student-centered, chances to handle materials or information and to observe events that might otherwise go unnoticed. This second category of activities is the more important for intellectual maturation of the student.

Too many students have never observed a ball repeatedly rise and fall, nor seen fresh bread dough expand. They don't know which way the wind blows. They've never taken apart a battery, a camera, or a gear system. They've never considered other lifestyles either, nor the social and environmental effects of exponential increases in energy use. They should get their hands and minds exposed to human variables as well as physical ones. After students handle materials and manipulate viewpoints, they may be ready for more formal analyses and (hopefully) will come to see social and environmental dynamics with new insights.

The limited research done so far on teaching energy conservation and need to change patterns of energy use suggests that practical experience is necessary. Measuring energy use at home and school, installing insulation or making a solar collector, experimenting with small changes in lifestyle, and exchanging viewpoints with others whose hobbies, habits, and career choices may be or have been affected by energy futures seem to be effective means of encouraging young people to make energy-use changes in their own lives.

Science and technology are important in outlining limits to energy alternatives, safety, storage, and environmental insults. However, national proposals that

call for major commitments to the development of more and more energy (delaying transition) draw attention away from the more significant social issues of energy distribution inequities, economic pressures, political repercussions, and international tensions. There are complex synergies whose existence are just becoming recognized, but are so much a part of the changing patterns of human life that they cannot be ignored. Therefore, this group of activities includes some that are related more to social studies and aesthetics than to pragmatic devices for measuring energy flows. This mix should emphasize the interdisciplinary and transdisciplinary nature of ENERGY to individual teachers.

Some of the articles prepared for this handbook are intended primarily for the teacher's information and background. If you want to introduce these topics to your students, adapt them any way you like.

Other articles "fit" more into one discipline than into another. Several are multidisciplinary, much depending on the emphases chosen by the teacher. Still others may involve other teachers, members of the community, families, or the school custodian. The summary and recommendations following are only suggestions, not limits. They may save time in making initial choices of activities to use in your classroom.

But don't stop there!

Energy Education:
General Objectives for Teachers

Successful energy education will encourage teachers:

1. To become knowledgeable about energy sources, uses, and conversions.

2. To recognize physical limits to energy availability and usefulness.

3. To recognize bases of human dependence on natural energy resources and the world-wide diversity of social responses to that relationship.

4. To become knowledgeable about environmental effects of energy exchanges and to recognize cost/benefit relationships and conflicts of values that need to be considered.

5. To know the "why" and "how" of energy conservation and to apply that knowledge.

6. To develop a forward-looking perspective; to broaden awareness of social, technological, and natural resource options; and to recognize the urgency of the need for planning.

7. To involve students in activities that help develop:

   a. their knowledge of energy relationships;

   b. their willingness to conserve and to make more productive use of resources;

   c. their awareness of value-bases for choices; and

   d. their talents for decision-making, planning, designing, and innovating that will affect the future.

Energy Education:
General Objectives for Students

Energy education will enable students:

1. To know more about energy sources, uses, conversions, and limitations.

2. To become aware of diverse, world-wide human responses to available energy resources.

3. To recognize that the environment is affected by energy exchanges, and that all energy use has costs as well as benefits for human society and its physical support system.

4. To develop a conservation ethic strong enough to be expressed in effective personal actions.

5. To acquire a sense of historical perspective that relates the present both to the past and to the future.

6. To develop decision-making skills and the confidence that personal and community choices and activities can affect the future in positive ways.

Key to Energy Activity Inventory

Type of Activity:

BI = background information for the teacher. All energy-educators should have this intrcduction, regardless of grade level or subject area.

TD = teacher-directed activities, like demonstrations or class discussions needing a moderator.

SC = student-centered activities, "hands-on" building or data-collecting experiences that can be done individually or in small teams. These often have directions and worksheets to be duplicated for student use. Teacher's notes usually supplement the student information, include hints on classroom management.

Subject Matter Areas:

HE = home economics

M = mathematics

IA = industrial arts

S = science

LA = language arts

SS = social sciences

Energy Activity Inventory

Concept: Energy is Basic

It exists in various forms and states that can be measured and appreciated in various ways. It flows and transfers itself. Life itself is energy conversion, a series of interactions with the physical world.

Title	Type	Subjects	Grades	Page
CALORIES, CALORIES	SC	HE, IA, S	9-12	173
CANNED SUNSHINE	SC	HE, IA, S	7-12	177
COLOR IT HOT	TD	IA, S	7-12	
ENERGY AND LANGUAGE ARTS	TD	LA, SS	7-12	
ENERGY AND LIFE	BI			19
ENERGY WORD GAMES	TD	HE, LA, S	7-9	185
GETTING FACTS ON ENERGY USE	BI			21
GO WITH THE FLOW	SC	IA, S	7-9	
HEAT CAPACITY AND TEMPERATURE	BI			22
HIGH COST OF LIVING - I STUDY OF A HERBIVORE	SC	S	9-12	
HIGH COST OF LIVING - II STUDY OF AN AUTOTROPH	SC	S	9-12	
MEASUKING ENERGY	TD	HE, IA, M, S	9-12	189
NEWS AND NOTES ON AGRICULTURE	BI			23
NEW/OLD IDEAS ON COOLING BY EVAPORATION	BI			25

Energy Activity Inventory

Concept: Energy is Basic

Title	Type	Subjects	Grades	Page
NOTES ON GRAPHS AND CHARTS	BI			27
PLANTS AND LIGHT ENERGY - I	TD	S	7-10	
PLANTS AND LIGHT ENERGY - II	SC	S	10-12	
POPSICLE POWER	TD,SC	S	7-12	
POTENTIAL ENERGY IN SUGAR	TD	S	10-11	
POWER PUFFS	SC	HE, IA, S	9-12	195
RENEWABLE VS. NON-RENEWABLE ENERGY	TD	IA, M, S	7-12	
SOLAR CLINOMETER	TD	IA, S	9-12	
SPOTTY POWERPLANT	SC	M, S	9-12	
SUN FUN	TD	HE, IA, S	7-9	197
SUN'S POSITION IN THE SKY	SC	IA, S	9-12	
UP WITH PEOPLE POWER	SC	IA, M, S	9-12	
WAXING HOT	TD,SC	IA, S	7-12	
WORDS ABOUT ENERGY - I	SC	HE, S	9-12	199
WORDS ABOUT ENERGY - II	SC	HE, LA, S, SS	9-12	205

Energy Activity Inventory

Concept: Energy Usefulness is Limited

Laws of thermodynamics describe physical constraints. Natural resources are limited in amount and usefulness. They require energy to extract. Exponential growth cannot continue indefinitely.

Title	Type	Subjects	Grades	Page
ELECTRICITY AND NATURAL RESOURCES	TD	SS	9-12	
ENERGY AND LIMITS	BI			37
ENERGY AND EFFICIENCY	BI			41
ENERGY RESOURCES	BI			49
ENERGY RESOURCE SUMMARIES	BI			53
FUEL SUPPLY AND DEMAND	TD	M, S	9-12	
GROWING TIME (Exponential Growth)	BI			67
LIGHT FANTASTIC, THE	BI			79
MODELING EXPONENTIAL GROWTH	SC	M, S, SS	10-12	
PLANET EARTH: SOME MEASURED LIMITS	TD	M, S	10-12	
SQUARING "ON THE DOUBLE"	TD	HE, M, S, SS	7-10	209
SUPER-TANKER EARTH	BI			81
THERMODYNAMICS: SOME BASIC ENERGY LIMITS	TD	HE, IA, S	7-12	213

Energy Activity Inventory

Concept: The Environment is Affected by Energy Exchanges

Mined fuel disrupts natural cycles. Alternatives must be developed but they will also have varying degrees of social, cultural, economic, and environmental effects.

Title	Type	Subjects	Grades	Page
BLOWING IN SOME CENTS	SC	HE, IA, M, S, SS	7-12	223
ENERGY AND HOME SITE DEVELOPMENT	TD	HE, IA	7-12	227
ENERGY DEBATE, THE	SC	LA, S, SS	8-12	
ENERGY AND POETRY	TD	LA, S	9-12	
GREENHOUSE EFFECT, THE	SC	IA, S	7-12	
HUMDRUM OR HOME DOME?	TD	HE, IA	7-10	229
INVESTIGATING PASSIVE SOLAR HOME HEATING	TD	HE, IA	7-12	231
MINI DRUM-WALL	TD, SC	HE, IA, S	7-12	233
NUCLEAR FUSION	BI			85
SIMPLE SOLAR OVEN	SC	HE, IA, S	7-12	241
SOLARIMETER, LET'S MAKE A	SC	IA, S	9-12	
SOLAR STILL, A	SC	IA, S	7-9	
WINDMILL, A CLASSROOM SAVONIUS	TD	IA, S	9-12	
WIND POWER	BI			89

Energy Activity Inventory

Concept: Energy Choices Affect Society

Lifestyles, employment, economics, quality of life, international relations, attitudes and choices are among elements directly related to energy use.

Title	Type	Subjects	Grades	Page
ENERGY AND STANDARD OF LIVING	TD	HE, S, SS	7-9	247
ENERGY AND TRANSPORTATION	SC	HE, LA, SS	9-12	249
ENERGY IN MANUFACTURING - I	SC	HE, SS	7-12	251
ENERGY IN MANUFACTURING - II	TD	HE, IA, M, SS	9-12	253
ENERGY OPINIONS AND PRIORITIES	SC	LA, M, SS	7-12	
HOW MANY HIDDEN HELPERS	BI			91
HOW NOW, DRY COW	SC	HE, M, SS	7-10	257
INTERDISCIPLINARY APPROACH	BI			96
LIFE STYLES AND ENERGY USE - I	TD	HE, SS	7-12	261
LIFE STYLES AND ENERGY USE - II	SC	HE, LA, SS	9-12	263
LIFE WITHOUT ELECTRICITY: A PEACE CORPS EXPERIENCE	TD	HE, M, S, SS	7-10	269
MAN, ENERGY, AND ENVIRONMENT: SOME ATTITUDES AND BELIEFS	TD	LA, S, SS	10-12	
NEWS WARM-UP	TD	LA, SS	7-12	
OIL EMBARGO AUCTION	TD	HE, SS	7-9	275
OIL, TRADE DEFICITS, AND THE 51ST STATE	TD	SS	8-12	
SOME ENERGETIC FIGURING	SC	M	8-10	
TRANSPORTATION FACTS	BI			99

Energy Activity Inventory

Concept: Conservation

Conservation means more productive use of necessary energy supplies and elimination of non-essential consumption. Careful use of fossil fuels can "buy time" for a more gradual energy transition.

Title	Type	Subjects	Grades	Page
BAKER'S DOZEN, THE	SC	HE, LA, S	7-9	277
CABIN FEVER I SURFACE AREA	SC	HE, IA, M, S	8-12	279
CABIN FEVER II INSULATION	TD	HE, IA, M, S	7-12	287
CABIN FEVER III INFILTRATION	TD	HE, IA, S	7-12	293
CABIN FEVER IV SITE AND PLANTINGS	TD	HE, S	9-12	297
CABIN FEVER V HUMAN FACTORS	TD	HE, SS	9-12	305
CHECKING WALL INSULATION	SC	HE, IA, S	7-9	309
CONVENIENCE AND ENERGY	TD	HE, M	7-12	311
ELECTRICITY FOR FUN, CONVENIENCE, WORK	SC	HE, SS	7-9	313
ENERGY AND AGRICULTURE	BI			100
ENERGY: WASTE AND PRODUCTIVITY	BI			103
FOOD-ENERGY CONSERVATION	SC	HE, S	10-12	317
HOMES AND SCHOOLS' ENERGY EFFICIENCY	TD	HE, IA, M, S	9-12	321
ON THE ROAD TO ENERGY SAVINGS	SC	HE, IA, M	9-12	323
READING ELECTRIC METERS	SC	HE, IA, S, SS	7-12	335
TRANSPORTATION: CARPOOLING SAVES	TD	HE, M, SS	7-12	347
WATERBAGS	TD	LA, S, SS	7-12	
WINDOW COVER PROJECT	SC	HE, IA, S	7-9	351

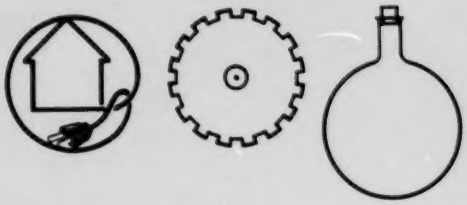
Energy Activity Inventory

Concept: The Future is Ours to Shape and Share

Time-sense must be developed, the present in relation to the past and to decisions affecting the future. "Quality of life" may be redefined.

Title	Type	Subjects	Grades	Page
ENERGY CONVERTERS AND POWER	TD	M, S, SS	10-12	
ENERGY AND THE QUALITY OF LIFE	BI			106
ENERGY TRANSITION AND CHALLENGE	BI			113
ENERGY USE AND DECISION-MAKING	TD	HE, S, SS	8-12	357
HISTORICAL DIGEST	SC	M, S, SS	9-12	
TRENDS AND CONSEQUENCES: The Futures Wheel	TD	HE, S, SS	9-12	363
YE OLDE TIMES, SUN PRESS, and STAR GAZETTE	TD	HE, LA, S, SS	7-12	367

PAGES 19-172 CONTAIN THE INTRODUCTION. THEY HAVE BEEN REMOVED AND MADE INTO A SEPARATE DOCUMENT - SE 034 677.



Calories, Calories, Who's Got the Calories?

Objective:

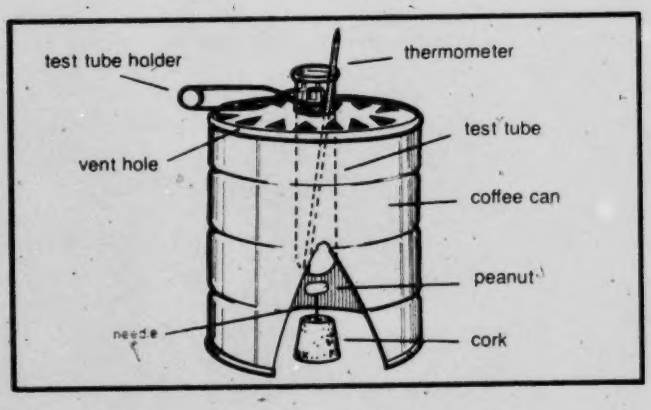
To measure the relative heat content of some common materials; to become familiar with some energy-related terms: fuel, calories, heat transfer, heat loss.

Materials:

Coffee can, metal punch, tin snips
Test tube and holder
Cork
Needle
Shelled peanuts, wood chip, sugar cube,* charcoal, coal, peat, praffin, paper wad, dried bread cube
Wooden kitchen matches

Procedure:

1. Set up the coffee can and other items as shown.



2. Put 60 ml of H_2O into a test tube. Record the water temperature. Then take the thermometer out of the test tube.

3. Decide which material you will test first. Weigh a small amount of it (0.2 to 0.3 grams). Don't use more than this. If you cause the water to boil off before the too-big sample burns completely, you won't have a way to know how much heat was transferred.

**The sugar cube will burn more easily if rolled in cigarette ashes first. Or use a clean cube and put it in position under the test tube. Then carefully, using an eye dropper, put two-to-three drops of concentrated sulfuric acid on the cube.*

4. Put the sample firmly on the needle which is, in turn, secured in the cork.

5. Use a match to start your sample burning. Then put the burning sample under the test tube as quickly as you can. Do not put your face over the top of the test tube and do not point it at anyone.

6. Watch the sample until it burns completely. When the flame goes out, take the temperature of the water in the test tube. Put this reading on your record sheet. Calculate the change in water temperature and the calories gained. One calorie is the heat required to raise the temperature of one ml of liquid water 1° C. You used 60 ml water, so you will multiply:

   $(°C_2 - °C_1) \times 60 =$ _____ calories

7. Repeat this procedure two or three times with the same fuel and compare results.

8. Choose another material, and weigh another small sample (0.2 - 0.3 g). Repeat the above procedure, recording water temperature before and after burning the fuel.

9. Complete your calculations on the record sheet. Compare results with classmates to determine which material transferred the most calories to the water.

Questions:

1. What was the most concentrated fuel tested by the class? (Look at the calories/g fuel.)

2. There are 1,000 gram-calories in one food Calorie or kilocalorie. Keeping this in mind, look up the number of Calories that bread, sugar, and peanuts are reported to have. How do your results compare?

3. What seemed to be the cleanest fuel you burned today? (Consider residue on the needle or on the test tube as "pollution.")

4. Why did you need to use a match to start the reation? Does it always take energy to get energy?

5. What is the reason for not trying to set fire to the sample while it is under the test tube?

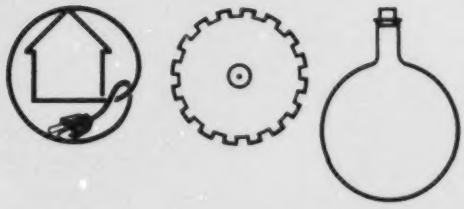
6. Based on this experience, define "fuel".

Student Record Sheet

CALORIES,
CALORIES!

Name _____
Date _____

Fuel Type	Fuel Weight	$^{\circ}C_1$ of H_2O (start)	$^{\circ}C_2$ of H_2O (at end)	Change, °C (C_2-C_1)	Calories gain (change x 60)	Cal/gm. Fuel



Canned Sunshine

You can get some basic information about collecting solar energy by building and testing a simple passive collector. How hot will a sun-exposed can get? How can the Sun's radiant energy be captured for heating your living and working areas? What are the essential parts of a solar collector? These are some of the many questions you may want to ask and try to answer as you do the following activity.

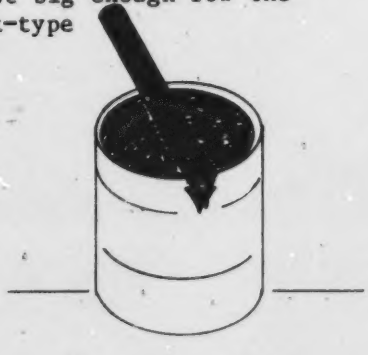
Materials:

One large can, about 12-14 cm diameter and 14-17 cm tall (a 3# coffee can or 2 1/2# vegetable fat can will do).
One smaller can, about 10 cm diameter and 1 cm or more shorter than the large can. (It must fit inside the larger can with room for a layer of insulation between the can bottoms and sides.)
Punch can opener
Standard laboratory thermometer (registering to 110° C)
Watch or clock with second hand
Plastic can lids, plastic wrap, waxed paper, colored cellophane, etc. as available
Duct tape
Rubber bands
Insulating materials: shredded paper, cotton, styrofoam, fiberglass, wood shavings, sawdust, cork, popcorn, as available
Paint and brushes or spray paint (flat black enamel)
Graph paper

Procedure:

1. Paint or spray the inside of the smaller can with black paint.

2. Punch one hole in the side of the small can, just big enough for the thermometer to slip through. (Position the hook-type can opener on the upper, open edge of the can. It will be easy to push in and all holes made will be the same distance from the top edge.)

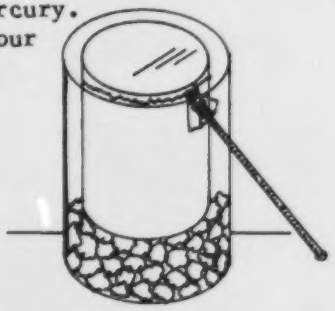


3. Punch a hole in the larger can the same way.

4. Choose one of the cover materials to stretch across the top of the small can. If necessary, secure it with a rubber band.

5. On the bottom of the larger can, put a layer of insulating material thick enough to raise the smaller can, when placed in it, so that its hole and that of the larger can line up.

6. Insert the thermometer bulb into the smaller can. Adjust the thermometer position so that you can easily read the mercury. Then close any irregular outside edges of your punched openings by taping small pieces of duct tape over any exposed areas.



7. Place your collecting cans in the sun and record the inside temperature each minute for 20 minutes. (If you have an outside table or a piece of board that everyone can use, tilt the surface until the cans' shadows are minimized. You will get best results when the Sun is hitting the can coverings as directly as possible. However, <u>all</u> cans should be positioned alike. In order to allow fair comparisons of your results using different materials, the collecting conditions must be the same.)

8. Have a classmate or the teacher record the air temperature of the surroundings while the collectors are "working".

9. Plot the data on a graph. Put temperature on the vertical axis and time on the horizontal axis. Use the background air temperature data also for a "base-line" comparison.

10. Cool down your cans and then put insulating material in all the space between the two cans.

11. Repeat procedures number 7 and number 8.

12. Compare results on the graph you already made. Connect the new data points with colored or dotted lines to distinguish them from the original ones.

13. Compare results with those of classmates who used different cover materials and/or different insulation.

<u>Questions</u>:

1. According to class results, which type of cover material appeared to be most effective? (Look for <u>change</u> in air temperature achieved as a measure of collector performance.)

2. Which type of insulation seemed to work best?

3. Why is it necessary to use insulation in a solar collector?

4. Of the materials that the class tested, which combination of glazing and insulation material would you recommend for a demonstration collector?

5. The collector you just used is like many used in solar-heated hot air systems. Can you identify the five basic components in a solar collector, using yours as a model?

6. If you were building a roof top collector for your home or school, what kinds of materials would you need?

Advanced Canning Research:

1. Put a lid on the outer can as well as on the inner one. Compare results with those from standard procedure.

2. Try different colors on the inner can surface. Is red or blue or green as effective as black? How does a shiny (unpainted) tin can perform?

3. Try painting the outer can as well. Does this affect collector performance?

4. Follow the procedure previously described with three different sizes of inner cans. A one-pound coffee can, no. 2 1/2 size fruit can, and 13 1/2 oz. tuna can, for example, all have the same diameter (about 10 cm) but different heights (approximately 13.8 cm, 11.7 cm, 5.7 cm respectively). Look for a relationship between temperature change, volume of air heated, and area of the glazed surface exposed to the Sun.

5. Must the cover admit light to be effective? Use a foil-covered can lid (shiny), a black-painted foil cover, and a black polyethylene cover as alternative "controls". Do they heat up as well as the clear-covered can? Do they cool as quickly? (Record cooling data every minute for 20 minutes with cans in the shade.)

6. Consider effects of wind, clouds, or extreme environmental air temperatures on a solar collector. Discuss ways to measure these effects.

7. Try tilting otherwise identical can collectors at various angles. Measure temperature changes as before. Do results suggest any improvements that would increase efficiency of a solar collector?

Teacher's Guide to Canned Sunshine

Basic information on solar collectors is provided on the next page. Use it for your information only or make copies for your class, as you choose.

This activity could be done with various-sized shoe boxes instead of cans. However, cans are sturdier and once painted and punched, the same ones may be used by several classes and/or reused on successive days without breaking down.

This procedure is based on the use of a standard household can-puncher. Warn students to avoid running fingers over the raw edges. A metal punch would make neater holes and eliminate need for the duct tape, if someone other than the students can prepare the cans ahead of time. Use a backing to prevent denting the can.

Collect cans or boxes well in advance of starting the activity. Be sure you have enough of the same sizes so that assemblies are comparable. Recommended are 1 lb. and 3 lb. coffee cans plus their plastic lids; 2 1/2-3 lb. vegetable fat cans with plastic lids; #2 1/2 size fruit cans (1 lb., 13 oz. net wt.) and large tuna fish cans (13 1/2 oz. net wt.).

The "advanced canning research" suggestion number 4 (for high school students) can best be done using the fruit, tuna, and 1 lb. coffee cans (all use the same size lid) for the inner can, thus keeping glazed area constant while varying the depth and volume of the can. Results can be expressed quantitatively and should suggest the advantage of a "flat plate" conductor over one that is deeper relative to sun-exposed surface.

Also, this advanced activity raises some interesting questions on heat vs. temperature. If all three collectors are receiving the same amount of sunlight (having the same kind and amount of surface exposed to the sun), why don't all three reach the same temperature at the same time? This is an opportunity to describe temperature as <u>average</u> heat of the surroundings, not total heat.

The basic activity will probably require three days total: one for construction of the collectors, one or two for data collection, and one for graphing and interpreting the results.

Divide the class into several groups, each of which is assigned different combinations of glazing and insulating materials. Be sure that each collects data under the same atmospheric conditions to eliminate differences in amount of sunlight available. Ideally, you will have an outside table or some large boards that everyone can use. Tilt the table or boards just enough that the can shadows are as small as possible, and no can is in a shadow. You will get best results when the sun is striking the collector covers as directly as possible.

Results will vary, depending on combination of insulation and glazing used and depending on the time of day and time of year. The greater the insulation and the better the insulation, the higher the temperatures expected. When air is the fluid conductor, a second layer of glazing (on the outer can) with air space between it and the inner can will usually increase the temperature rise.

Evaluate students on ability to follow instructions and to work with others; on organization and analysis of the data gathered, including graphs prepared and explained; on answers to the questions. A sample graph is provided from "Solar Energy Project" of the State Education Department of New York. This activity is an adaptation of one included in their 1979 publication.

Encourage "outside research" on solar collectors and answers to question 6. If possible, identify a local contractor, utility or business representative who can provide information on types of solar collectors now in use and possibilities of jobs making or servicing them. Have this person visit the class or suggest a time when students may visit or telphone to obtain additional information.

The hole-punching routine is based on the assumption that you have 25-30 cm long Celsius thermometers already in stock. If reliable small thermometers are available (for example, those from A.S. & E., 955 Massachusetts Ave., Cambridge, MA. 02139 for about $.71 each) and if all you cover materials are transparent, holes may be unnecessary. The thermometer can stand inside the can or box and be read through the cover. Eliminating holes means that opaque covers cannot be tested, but another variable may be introduced instead. Water or other liquids may be used for the collecting fluid.

SOLAR COLLECTORS:

A collector for a solar heating system has five basic parts:

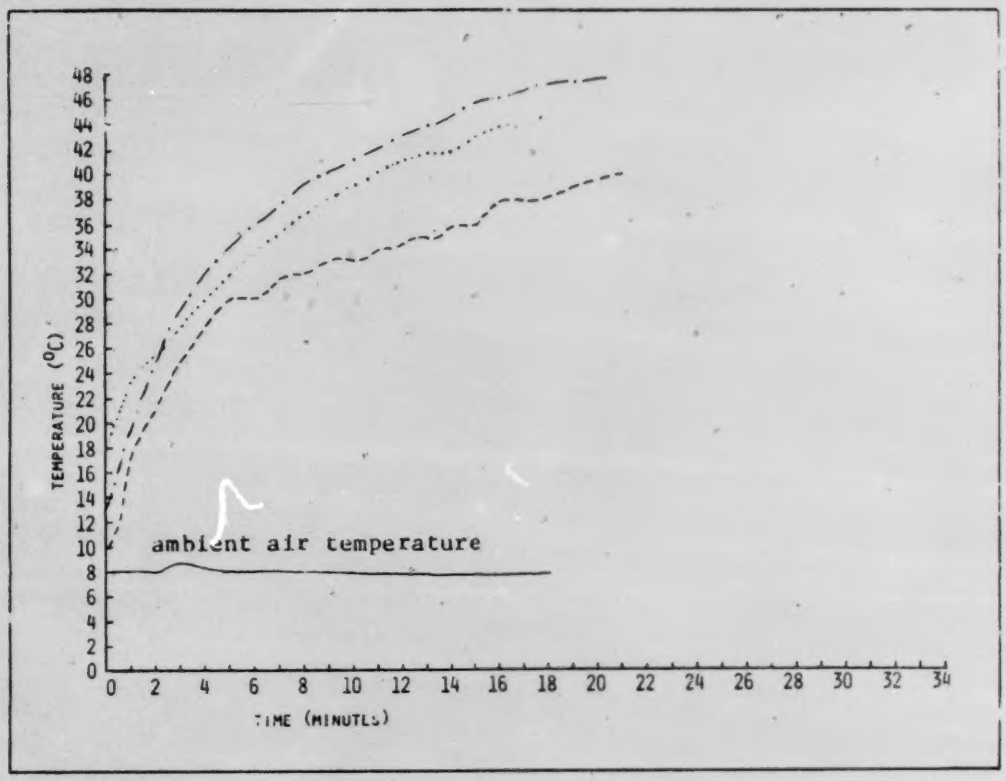
1. The cover or glazing material which (ideally)
   lets in almost all of the incoming solar radiation;
   does not let energy out again;
   is unbreakable;
   can withstand a wide range of temperatures without cracking or decomposing.

2. The collector plate which absorbs the energy admitted by the cover and
   is usually metal (copper and aluminum are typical choices);
   is almost always covered with a dark coating that has to be stable at high temperatures.

3. The housing or collector box surrounds and/or supports the other parts of the collector;

4. The insulation surrounds all unglazed sides of the collector box in order to reduce conduction losses;

5. The fluid (either air or a liquid, commonly water and antifreeze) which transfers solar heat to another substance to be heated (air in living areas or a storage medium).



Sample graph for CANNED SUNSHINE

Symbol	Insulation Type	Inner Cover	Outer Cover
__.__.	styrofoam	clear plastic	clear plastic
.....	rock wool	clear plastic	clear plastic
------	fiberglass	glass	none

Energy Word Games

1. ENRGY Bingo

Ordinary bingo requires only the ability to hear numbers called, to recognize them on a card, to cover them on the card when called, and to say "Bingo!" when five adjacent numbers are covered in a row, column, or diagonal. ENRGY requires additional skill: Knowledge of some energy-related terms. The objective is to enhance retention of what the student has learned about energy, to motivate learning additional facts, and to point out gaps in knowledge.

a. Advance preparation:

Cards must be developed like the following example. No two should be exactly alike. Words from the accompanying list are suggested. Add others that are appropriate for your classes.

Also, prepare in advance a short descriptive sentence for each energy-related word used on your game cards. Put each sentence on a separate slip.

b. Play:

To begin play, the caller will shake up the word slips in a 3 lb. coffee can or other suitable container. Then he will draw and read one slip at a time. Players must decide which term is being described and, if they have that word on their cards, cover it. From then on, it is played just like conventional bingo.

E	N	R	G	Y
evaporate	entropy	R-factor	geothermal	hydro-power
conduct	nuclear	recycle	gas	bicycle
convect	fusion	FREE	coal	flywheel
electric	fission	retrofit	petroleum	Calorie
EER	insulate	radiation	quad	fuel

2. Crossword puzzles and word-maze games

Provide graph paper with 1/2 inch or cm-squares. Encourage students to make word puzzles using

a. as many "energy words as possible; or
b. as compact a format as possible (measured in ratio of squares used/squares available); or
c. a graphic energy-related design within which selected words will "fit"; or
d. a special theme, like travel, houses, electricity, conservation, alternative sources, etc.

3. Charades

a. Advance preparation:

Have energy vocabulary written onto separate slips of paper or file cards and placed in a shoe box or a 3 lb. coffee can.

b. Play:

A student will draw out one of the energy terms. This student must pantomime or find a way to describe his energy-related feature without saying anything. Some fingerspelling may be allowed. The student who first guesses the term in question will then get the privilege of drawing out another slip of paper and repeating the process for a different energy word.

4. Password: Energy Style*

a. Advance preparation:

Make 3 clue cards, one large one to show the audience and 2 small ones, one for each team. (The card goes only to the contestant giving the clue.) Use heavy paper so writing will not show through. Use the ENERGY WORDS FOR GAMES or any others of your choice.

b. Play:

Bring four students to the front of the classroom and have them alternate giving clues and receiving clues (two teams). Give points according to how many clues have been given--10 for the first clue, 9 for the second clue, and so on down to 1 point before you reveal the word to the guessing partner. Game is 21 points.

**This is one of a group of learning games suggested by Miriam Colvin of Hawkeye, Iowa; Dorothy Kruse of New Albin, Iowa; and Ada Narem of Meservey, Iowa in an energy unit developed during a DOE-sponsored workshop directed by Ella Jedlicka at U.N.I., Cedar Falls, Iowa, June 1978.*

5. Riddles

Have students (individually) write words that are descriptive of or associated with some energy source, energy use, energy effect, or energy-related technology. Then ask each student to rank these "word-clues" from easiest to most difficult (a scale of 1-10 is suggested) and to rewrite them in that order.

Students can then test these riddles on each other, supplying the most difficult clue first (ten points to receiver who is successful on this one) and the rest in order, with easiest last (only one point for guessing correctly on the last clue). Have class look for the most interesting and most challenging riddles. Students who (unknown to each other) had chosen the same words to "riddle" may refine their clues to incorporate the best of each. Or others in the class may have suggestions for perfecting the riddles. Encourage combinations and additions. Then have students rewrite their clue lists and arrange to have the riddles used in another class. Prepare an appropriate prize for the contestant who answers most efficiently (that is, using least clues). An example of a "sequential clue" riddle is:

Clue	Points
distant	10
diffuse heat	9
fusion	8
bright	7
daily	6
favors equator	5
trapped in plants	4
worshipped by many	3
life source	2
fireball	1

Answer: The SUN.

ENERGY WORDS FOR GAMES

air conditioning
air pollution
appliances
atom
barrel
bicycle
boiler
brown out
BTU
Calorie
car pool
caulking
Celsius
coal
coal gasification
condenser coil
conduction
conservation
consumer
convection
coolant
critical mass
damper
EER
efficiency
electricity
energy
energy transition
entropy
evaporation
exchanger
Fahrenheit
fiberglass
filters
fireplace
fission
fluorescent
flywheel
food chain
forced air
fossil fuels
friction
frost free
fuel
fuel cell
furnace
fusion
gasket
gasoline
generator
geothermal
heat
heat pump
horsepower
hot water
hydroelectric
incandescent
infiltration
insolation
insulation
internal combustion
joule
Kelvin
kilogram
kilowatt
kinetic energy
lifestle
megawatt
meter
methane
natural gas
nuclear power
oil shale
overhang
peak load
petroleum
photosynthesis
potential energy
pressure cooker
propane
quad
R-factor
radiation
radioactivity
recycle
retrofit
solar
solar collector
specific heat
storm window
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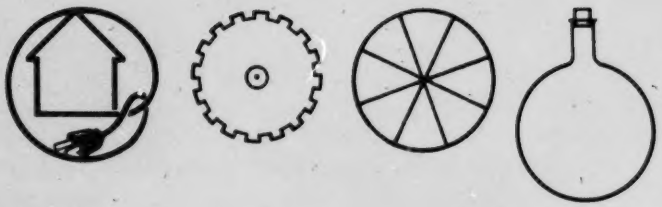
sun
temperature
thermal efficiency
thermal pollution
thermometer
thermostat
triple pane
vapor barrier
waste
weatherstrip
wind brea
work



Measuring Energy

Introduction:

There are many different units used to measure energy. The mix of terms used in various media can be confusing. Many of them are interchangeable, but some are not. How did such a jungle of jargon grow?

Background:

1. Various forms of energy were recognized and studied by different people in different countries. One researcher devised units for radiant energy, for example; others worked with electricity and gave their names to its measures; mechanical energy was quantified independently at a time when equivalence to other forms of energy was not recognized. We now realize that these units can be converted back and forth.

2. Two systems of measurement are involved. The eclectic British system borrowed measurement terms from many countries. The French devised a "universal one" based on powers of ten. Both systems have been widely used, with engineers in the U.S. usually using British terms like "B.T.U." and scientists using metric ones like "calorie".

3. Two different ideas, power and energy, are often used interchangeably in popular writing, adding to the confusion. Energy is the ability to make materials hotter, higher, or denser or to cause other changes. Power is a measure of how fast such transformations are done, or can indicate how concentrated the energy source is.

   There are two principal units of power, the horsepower and the watt. One horsepower is 550 foot pounds per second and a watt is one joule per second. Kilowatts and megawatts are 1,000 and 1,000,000 watts respectively, measures of flow of electricity. In order to know how much energy is used by a power source, the amount of time that power was used must be known.

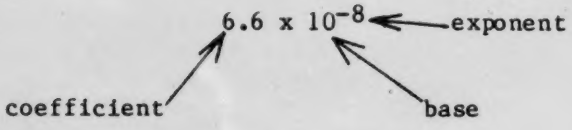
   Energy = Power x Time

4. Range of the units of energy varies. Some quantify very tiny transformations (like "electron volts") and others refer to gross consumption (like "quads"). Because of the wide range of energy measurements, including splitting of one uranium atom (.00000000001 Calories) and the annual heat output of the Sun (10,000,000,000,000,000,000,000,000,000,000,000,000,000 Calories) a convention has been adopted to make writing and computing with these numbers somewhat easier.

The shorthand way of expressing vary large and very small numbers is called POWERS OF TEN. One thousand (1,000) becomes 10^3 or 1 x 10 x 10 x 10. One million (1,000,000) becomes 10^6 and one billion is 10^9. The annual solar output becomes 10^{37}. The "exponent" or small raised number after the ten indicates how many tens were multiplied together (or how many 0's should follow the 1).

Very small numbers are indicated by a minus sign in front of the exponent.

Example:



The negative exponent indicates how many places to the left the decimal point should be placed. For the example above, the equivalent decimal is 0.000000066.

Common Units of Measure for ENERGY:

barrel: a liquid volume equal to 42 gallons or 159 liters or 0.159 m^3; usually used for petroleum

barrel of oil equivalent: an amount of energy typically contained in one barrel of petroleum--5.8 x 10^9 joules or 5.5 x 10^6 BTU or 1.39 x 10^6 Cal.

B.T.U. (British Thermal Unit): the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. One BTU is approximately equal to the amount of heat given off by a wooden match. A pound of coal contains approximately 13,000 BTU of chemical energy.

calorie: the amount of heat required to raise the temperature of one ml of water one degree Celsius.

Calorie: the kilocalorie or "food Calorie", the amount of heat necessary to raise the temperature of 1,000 ml of water one degree Celsius.

foot candles: unit of direct illumination at a given location, equivalent to the energy of light received on a surface at a distance of one foot from a standard candle. It is equal to one lumen per square foot.

foot-pound: English unit of mechanical energy, or work, the amount needed to lift one pound object one foot off the Earth.

horsepower: another unit of mechanical energy, the equivalent of 33,000 ft.-lbs. of work per minute (or 550 ft-lbs. per second) or 42.4 BTU's per minute. In electric power units, one horsepower-hour is about 0.75 kilowatt-hr.

joule: a metric unit of work, mechanical energy, and heat; approximately equal to 0.74 ft.-lbs. or 0.00096 BTU or 0.24 calorie. It is defined as the energy needed to raise a one kg. object one meter off the earth. It is also defined as the energy expended in one second by an electric current of one ampere in a resistance of one ohm.

kg coal equivalent: unit of heat energy often cited in U.N. statistics for comparison of solid, liquid and gaseous fuels. One kilogram coal equivalent is 7,000 Calories or 28,000 BTU.

Langley or Ly: unit of solar energy, radiation intensity equivalent to 1.0 calorie/cm^2. It can be used as a power unit when flow over time is expressed as Ly/min. or Ly/hr. or Ly/day. One Ly/min. = 221.2 BTU/hour/ft^2. One ly/min. also = 697.3 watts/m^2 or 16.74 kwh.

quad: the gigantic energy unit used to measure how much entire countries consume each year; it represents a quadrillion BTU's or the amount of energy in 172 million barrels of oil. United States citizens used about 78 quads of commercially supplied energy in 1979.

watt: a measure of electrical power, one joule per second. Wattage is a product of the voltage (measure of the "pressure" in an electrical circuit) and the amperes (current or flow of electricity). One volt and one amp applied to a circuit for one hour would use one watt-hour of electricity. One thousand (1,000) watt-hours or a kilowatt-hour is the unit most often used to measure electrical consumption. A 100 watt bulb burning for one hour has used 100/1,000 or 0.1 kwh of electricity. The same bulb lit for ten hours would use ten times as much power or one kilowatt-hour.

Activity Suggestions:

1. Use copies of Energy Unit Conversion Charts A and B for students' practice in handling "powers of 10". Provide Chart A and ask the students to rewrite each conversion factor in exponential form. Another day use Chart B as an "exam", asking students to rewrite each factor as a conventional integer or decimal.

2. Have students look through DOE pamphlets, extension service and utility company brochures and reports, popular magazine articles on energy topics, home utility bills, appliance handbooks or texts, science textbooks, and other available literature for examples of common usage of energy units.

a. Which unit(s) appear most often? Why?

b. Which is easiest to visualize or otherwise remember? Why do you think so?

c. If you could "standardize" energy units, what measurement would you use? Give a reason for your choice.

d. Why is it important to measure energy anyway?

3. Using mail order catalogs, appliance owners' handbooks, and automobile owners' manuals, identify the energy and power units used to describe various movers, heaters, and lights. Which items require the most energy for their use (daily, weekly, yearly)? Which require very concentrated energy sources? Which could operate or be made to operate on renewable resources?

Energy Unit Conversion Chart A

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal		4,200	.0012	3.97	3,090	.00156
joule	.00024		.00000028	.00095	0.74	.00000037
kwh	860	3,600,000		3,400	2,700,000	1.3
BTU	.252	1,055	.000293		778	.00039
ft.-lb.	.00032	1.4	.00000038	.0013		.0000005
hp.-hr.	640	2,700,000	0.75	2,500	9,980,000	
barrel of oil equivalent*	1,386,000	5,800,000,000		5,500,000		

Note. *Numbers have been rounded to two significant figures in most cases. Calorie is the kilocalorie or "food Calorie."*

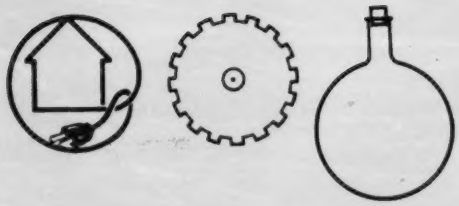
*42 U.S. gallons.

Energy Unit Conversion Chart B

	Cal.	joule	kwh	BTU	ft.-lb.	hp.-hr.
Cal.		4.2×10^{3}	1.2×10^{-3}	4.0	3.1×10^{3}	1.56×10^{-3}
joule	2.4×10^{-4}		2.8×10^{-7}	9.5×10^{-4}	0.74	3.7×10^{-7}
kwh	8.6×10^{2}	3.6×10		3.4×10^{3}	2.7×10^{6}	1.3
BTU	2.5×10^{-2}	1.1×10^{3}	2.9×10^{-4}		7.8×10^{2}	3.9×10^{-4}
ft.-lb.	3.2×10^{4}	1.4	3.8×10^{-7}	1.3×10^{3}		5.0×10^{-7}
hp.-hr.	6.4×10^{2}	2.7×10^{6}	0.75	2.5×10^{3}	2.0×10^{6}	
barrel of oil equivalent*	1.4×10^{6}	5.8×10^{9}		5.5×10^{6}		

Note. *All figures are rounded to 2 significant figures.*

42 U.S. gallons.



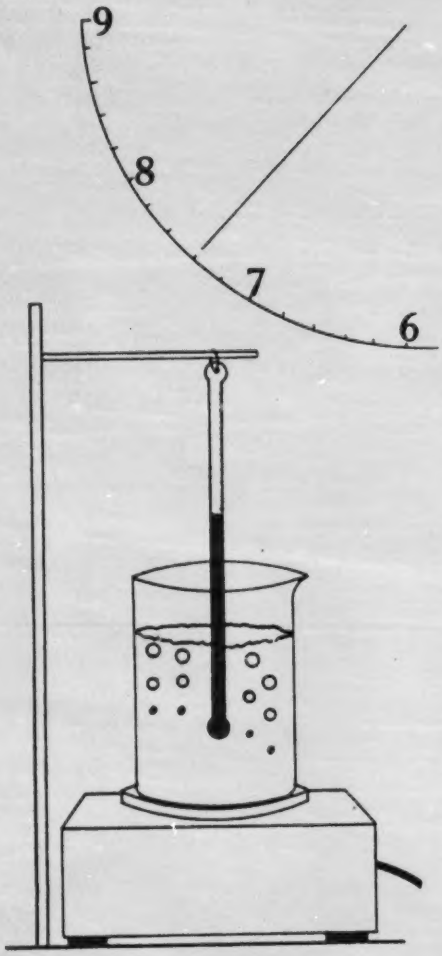
Power Puffs

Objective:

To demonstrate efficiency of an electric heater; to observe characteristics of heating and cooling of water.

Materials:

Electric hot plate
Thermometer (0-100°C range)
500 ml pyrex beaker or
other heatable container
300 ml water
Clock or watch with
second hand



Procedure:

Check and record the power rating of the hot plate before using it. Put the beaker with water on the hot plate and hang the thermometer in the water so that it doesn't touch the glass.

Turn on the hot plate. Note time and starting temperature of the water. Record the water temperature every minute for 15 to 20 minutes (water should be boiling). Then turn off the hot plate and continue to record the water temperature as the water cools.

Questions:

1. Make a graph of temperature vs. time. Explain any changes in direction of the line.

2. Calculate the calorie exchanges during the first six minutes (1/10 hour) of heating.

   Subtract the beginning temperature (T_1) of the water from the ending temperature (T_2) in °C and multiply by the volume of water (300 g or 300 ml) to obtain the heat energy absorbed by the water (in calories).

   Reminder: One calorie is the amount of heat required to raise the temperature of one gram of water 1°C. A food Calorie is 1,000 calories or the amount of heat necessary to raise one kilogram (one liter) of water 1°C.

   a. The temperature change observed in the first six minutes was _____°C x 300 ml water = _____ calories absorbed by the water.

      Then multiply the power rating of the hot plate (in watts) times the time of operation (in hours) times a conversion factor of 860 calories/watt-hour to obtain the total heat energy used in operation of the hot plate (in calories).

   b. During the first six minutes, the hot plate used _____ watts x 1/10 hour x 860 = _____ calories.

      The efficiency of the hot plate operation can be expressed as a ratio between $\frac{\text{heat absorbed}}{\text{heat provided}} \times 100\%$

   c. The heat absorbed by the water (a) _____ ÷ heat provided by the hot plate (b) _____ x 100% = _____% efficiency of operation.

   d. Where did all the heat from the hot plate go?

3. Do the same kind of calculations for the entire heating period (1/4 or 1/3 hour, 15 or 20 minutes).

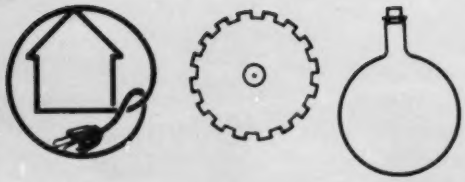
4. How do your results in question 3 compare to calculations in question 2? Explain any differences.

5. What do your observations suggest about boiling?

6. How could you improve the efficiency of your water-heating system?

Suggestion for extended activity:

Heat, boil, and cool some other liquids (isopropyl alcohol, salt water, vinegar, a 50-50 mixture of distilled water and alcohol) and graph their temperature-time curves. Do they heat at the same rate as water, boil the same way, cool like water?



Sun Fun

"Gather ye sunbeams while ye may...."

Background:

Fuel is a form of concentrated energy that can be rapidly released. Sunshine comes in slowly and steadily, but it is low-power in its "raw" state. Natural concentration of it (by plants, animals, and geophysical processes) required millions of years. Research scientists are looking for ways to speed this process and to concentrate solar energy by means of human inventions.

In order to collect sufficient solar energy in one location at one time for high-heat processes, concentrations and/or reflectors are needed. One of the experimental ways of generating electricity from sunlight, for example, uses hundreds of mirrored reflectors to beam sunlight onto a boiler, changing its contents to steam that turns a conventional turbine. Historically, curved lenses were known as "burning glasses". Eighteenth century French scientist Lavoisier fused metals by concentrating sunlight through an array of hollow glass lenses and a parabolic reflector.

Objectives:

To expose students to the challenge of directing enough solar energy onto a piece of paper to raise it to kindling temperature;

To develop awareness that there is a cost (materials and know-how) in using "free" sunshine;

To introduce some vocabulary: collecting, focusing, concentrating, power.

Procedure:

On a sunny day, take students outdoors. Provide them with magnifying glasses and ask them to determine how much time is required to ignite a small piece of paper with one. (Place the paper on a sidewalk, a brick, or a glazed tile.)

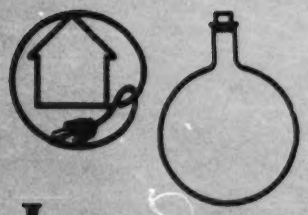
Encourage them to repeat their efforts, using small pieces of flat glass, small pieces of mirror, or eyeglasses. Set a time limit for these trials (ten minutes for each trial is reasonable on a clear day) so that there is class time left for discussion of why some pieces of glass can light a fire and others cannot.

If you have or can borrow a Fresnel lens and holder, you may want to set it up to demonstrate its effectiveness in concentrating solar energy. It can ignite a piece of paper in seconds.

Results:

Most students can ignite the paper with a magnifying glass. Steady hands and patience are required to keep the light beam in the same spot for a few minutes. Eyeglasses may or may not work, depending on their thickness and curvature.

The flat glass will not start a fire. Students will notice that no beam or white spot can be derived from its use. The single mirrors also will not have any noticeable effect. However, it may be possible to ignite paper if a dozen or more students cooperatively reflect light onto a single small piece of paper.



Words About Energy - I

Crossword Puzzle by Anita Gorden
West Liberty High School
West Liberty, Iowa

Energy Crossword Puzzle
by Anita Gorden*

Background:

This puzzle was designed for high school students investigating energy. Terms used in the crossword puzzle are basic energy concepts, in order for this learning activity to be applicable to energy units in housing, clothing, foods, personal care, and family living.

Intended Use:

This puzzle can be used as a teaching aid, unit review, or as a self-instructional learning experience.

Objective:

To familiarize the student with key terms and facts related to energy.

Directions:

ACROSS:

2. A nuclear reaction involving the combination of smaller particles into larger ones with the release of energy.

5. A residue of coal used for fuel.

7. Our source of solar energy.

8. The quantity of heat required to raise the temperature of one pound of water one degree F.

10. Identifies natural or synthetic fabric.

11. Less than one percent of the atoms of this element will produce energy in a nuclear reactor.

13. Not any.

14. Basic building block of all matter.

15. A means of payment for your utility bill.

16. The outlay or expenditure for energy.

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*This activity was written at a DOE-sponsored workshop directed by Ella Jedlicka at U.N.I., Cedar Falls, Iowa, June, 1978.

18. Official examination of building for heat usage.

20. This energy resource is formed from the fossils of ancient plants and animals.

22. The amount of force employed to move a quantity of electricity.

24. Radiant energy which an observer can see.

25. This type of bulb gives more light per watt of electricity than others.

28. The energy produced by splitting atoms in a nuclear reactor (2 words).

29. Insulation in the _____ can cut energy loss through the roof.

32. Designed to prevent heat loss (clue: _____ underwear).

37. A demand for repetition.

40. Series of events that recur regularly.

41. A large international petroleum company.

43. The external conditions and influences affecting your life and development.

44. Recent; fresh.

46. A unit that measures the rate at which energy is produced or used.

48. Perennial plants that are a source of a fuel.

50. American demand for this resource has doubled repeatedly every 10-18 years.

51. A substance used to produce heat energy.

52. After the expected time.

54. Emission and propagation of energy through space.

56. A material essential to every living thing.

57. Department of Energy.

59. A solid fuel, mostly carbon.

60. Making only one _____ or less to the grocery store each week saves energy.

62. Source of warmth and light.

64. An enclosed structure in which heat is produced.

67. _____ consumption is expected to triple in the next twenty years if it follows past trends.

69. Prudent; thrifty.

71. An electric current that reverses its direction at regularly recurring intervals.

72. The largest energy consumer in the world.

73. Extending for a considerable distance.

DOWN:

1. This puzzle contains words _____ should know concerning energy.

2. Federal Housing Administration.

3. One effective energy conservation measure for mobile homes is building an enclosure called a _____ to keep wind from sweeping under the floor. (Hint: article of clothing for women).

4. When the television is _____ and no one is watching, energy is being wasted.

5. Your use of economic goods to supply your wants and needs.

6. This is a very convenient power supply.

7. There is no electrical (7 letters), so it's made to order when you need it.

9. A device for regulating room temperature.

12. Anything which is solid, liquid, or gas.

17. A liquid fuel formed from the fossils of animals and plants.

19. The measure of resistance to heat flow; used to rate insulation.

21. Radiation energy from the Sun.

23. Coal, oil, and natural gas are examples of _____ fuels because they originate from geologic deposits of ancient plant and animal life.

26. An appliance is _____ if it has a high ratio of useful work performed in relation to the amount of energy it uses.

27. Reduces drafts by making sure that all doors and windows fit their frames snugly.

30. When washing clothes, use _____ water to conserve energy.

31. The time rate at which work is done.

33. A southfacing _____ receives maximum Sun in the winter.

34. Hearty approval.

35. Circulate; move freely.

36. A generative force.

38. If present trends continue, will the American energy demand remain constant until the year 2000?

39. Natural gas, coal, oil, and wood are natural _____.

42. Substances that can slow down the flow of heat and sound in your home.

45. Energy that escapes as heat without doing any work.

47. Nearby (clue: your _____ extension office is a source of energy information).

49. An instrument for measuring the amount of fuel used.

52. Heat, power, water, telephone.

55. One of nature's best insulators comes from birds.

58. Large group of people enjoying available energy.

61. Exchanging money for energy.

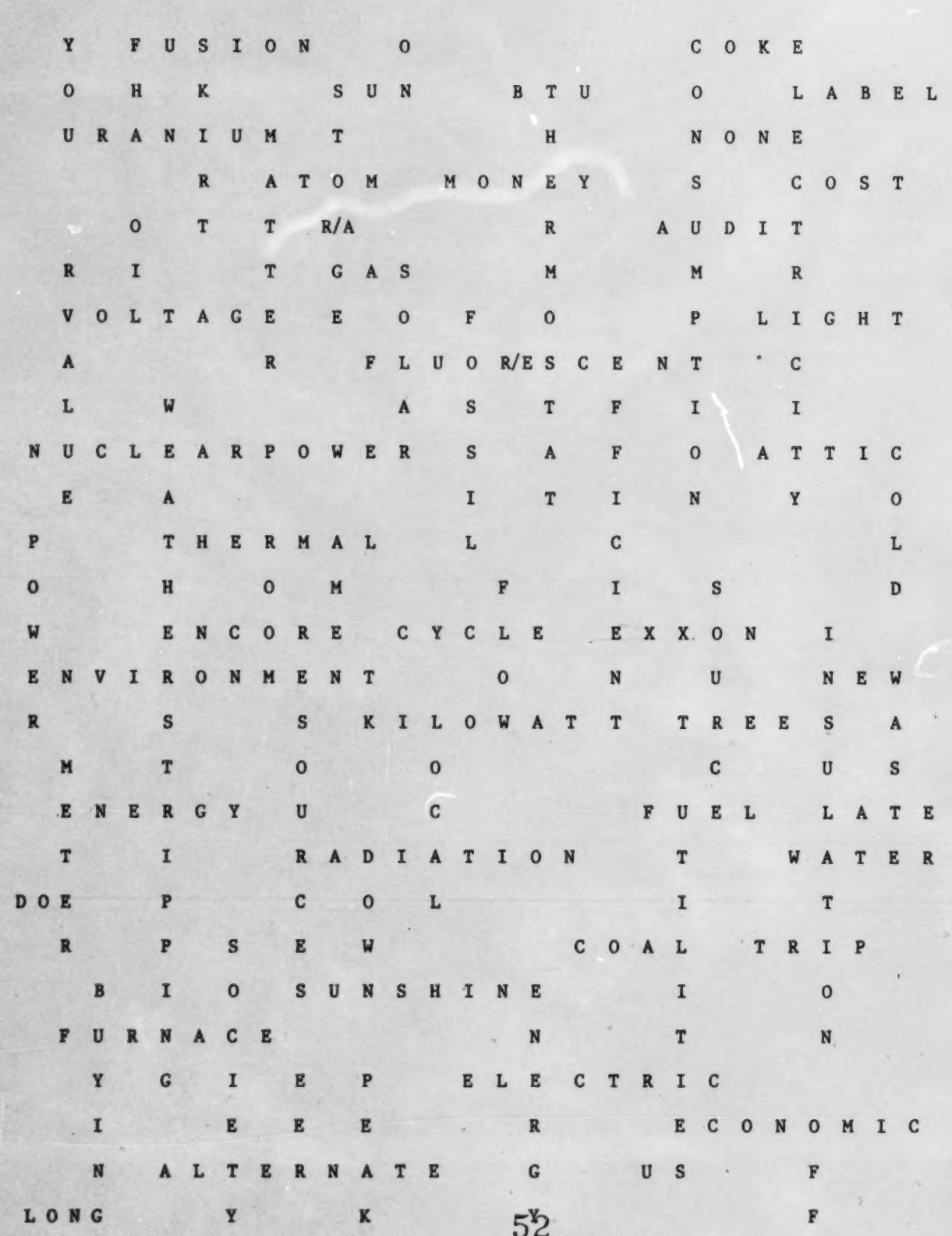
63. Able to do work.

65. Energy Efficiency Ratio.

66. Highest portion of the daily energy load.

70. The way to leave lights in an empty room.

Gorden Energy Puzzle Key


Y F U S I O N O C O K E
O H K S U N B T U O L A B E L
U R A N I U M T H N O N E
R A T O M M O N E Y S C O S T
O T T R/A R A U D I T
R I T G A S M M R
V O L T A G E E O F O P L I G H T
A R F L U O R/E S C E N T C
L W A S T F I I
N U C L E A R P O W E R S A F O A T T I C
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O H O M F I S D
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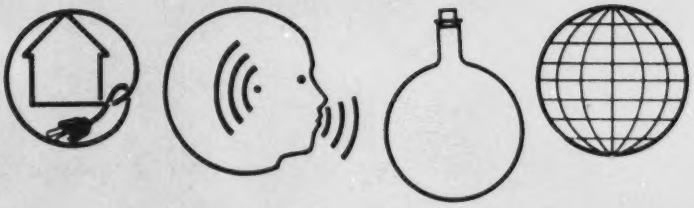
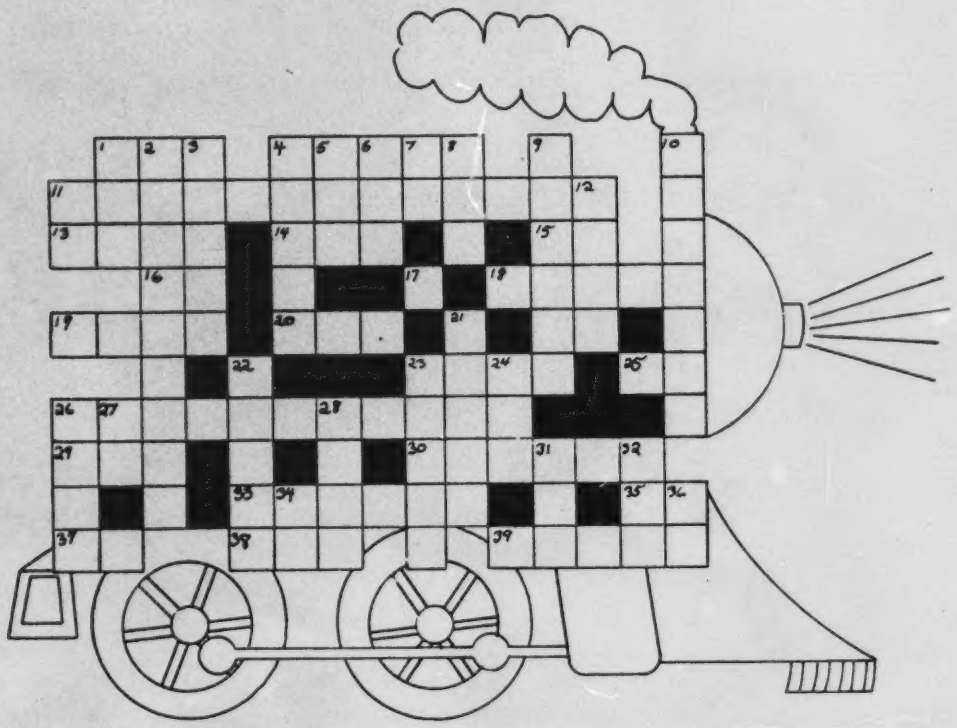


Words About Energy - II



The Energy Express(ion)

Directions:

Put a little energy into expanding your vocabulary. Then you'll be able to keep on the track and steam ahead by observing these signals:

ACROSS:

1. To choose freely.

4. What a kite or glider will do in a good wind.

11. Moving because of the application of heat (adj.).

13. Exhausted, run out, hollow (phonetic spelling).

14. The side sheltered from wind.

15. Sometimes this is an energy-saving response.

16. Worker providing medical services at low-energy cost (abbr.)

17. Initial of a scientist who devised a centigrade thermometer.

18. How to survive in challenging times.

19. Stored solar energy resource most used by less developed countries.

20. Roentgen equivalent man, (abbr.) unit of biological dose of radiation.

23. Mode of transportation that is an energy-efficient freight mover.

25. The most basic energy-producing business (abbr.).

26. Power for small motors.

29. Engineers' measure of heat; the amount of heat required to raise one pound of water 1° F.

30. Metric unit of time; fraction of a minute.

33. Person who lives in the countryside, known as a back-to-the _____.

35. Domesticated animal that is a major power source in some developing countries.

37. Warm prevailing wind.

38. Unit of weight (British system) (abbr.).

39. Energy-saving devices; furniture usually found wherever people live or work.

DOWN:

1. Unit of electrical resistance.

2. Naturally occurring mixture of crude oils.

3. Turn toward a particular direction or course; as in, "Car dealers report that the buyers' _____ is toward small cars."

4. Renewable energy on which all living things depend.

5. Kind of poem. Shelley wrote one ". . . to the West Wind."

6. Intelligent response to calls for conservation; a vote in favor of energy saving.

7. Symbol of radon gas, a by-product of radioactivity.

8. Useful tool for processing man's oldest fuel.

9. Invisible energy source that can provide electricity or hot water in some locations.

10. Electrical potential expressed in volts.

11. Thermal energy (abbr.).

12. Solid, non-renewable, fossil fuel.

21. Very heat-absorbent liquid.

22. Equipment for separating fresh water from salt or alcohol from grain; may be directly solar-powered.

23. What warmer fluids have always done.

24. International Yodeling Contest (abbr.), a low-energy production of musical entertainment.

26. What the tide does daily.

27. The kind of energy eye-witnesses depend on (abbr.).

28. Charged particles involved in chemical and electrical energy transfers.

31. Number of times a human being can completely stop using energy.

32. Department of Transportation.

34. "Absolute" (abbr.).

36. Unknown quantities.

Teacher's Guide to Words About Energy - II

Answer Key

		1	2	3		4	5	6	7	8		9			10
		O	P	T		S	O	A	R	S		W			V
11	T	H	E	R	M	O	D	Y	N	A	M	I	C		O
13	E	M	T	E		L	E	E		W		N	O		L
			R	N		A			C		A	D	A	P	T
19	W	O	O	D		R	E	M		W			L		A
			L		S				R	A	I	L		A	G
26	E	L	E	C	T	R	I	C	I	T	Y				E
29	B	T	U		I		O		S	E	C	O	N	D	
	B		M		L	A	N	D	E	R		N		O	X
37	S	W			L	B	S		N		S	E	A	T	S

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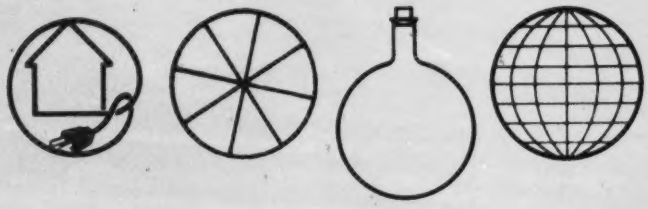


Squaring "On the Double"

Objective:

To model exponential growth or "doubling time."

Materials:

Sheets of graph paper with 1/4" or 5-6 mm squares.

At least four colored pencils or crayons or colored pens per student.

Watch with second hand or minute-timer.

Procedure:

Tell the students that you will give them one minute to color a square on their graph paper. Of course they don't need that much time, but give them a full minute anyway.

Then ask them to use another color on two squares during the next minute. Ask for a third color and four squares during the third minute. Keep a steady pace with no waiting time between minutes. Ask for eight squares during the fourth minute, etc. until there is no more room on the paper.

Table A

Minute	Number of Squares to Color		Total Colored
1	1	(2^0)	1
2	2	(2^1)	3
3	4	(2^2)	7
4	8	(2^3)	15
5	16	(2^4)	31
6	32	(2^5)	63
7	64	(2^6)	127
8	128	(2^7)	255
9	256	(2^8)	511
10	512	(2^9)	1023

Expected Results:

Depending on size of the squares on the original graph paper, students may be able to color in eight or nine doublings before running out of space. Note to students how easy (plenty of time) it was to color in the first six minutes worth of squares, but how hurried they were during the last minutes of coloring.

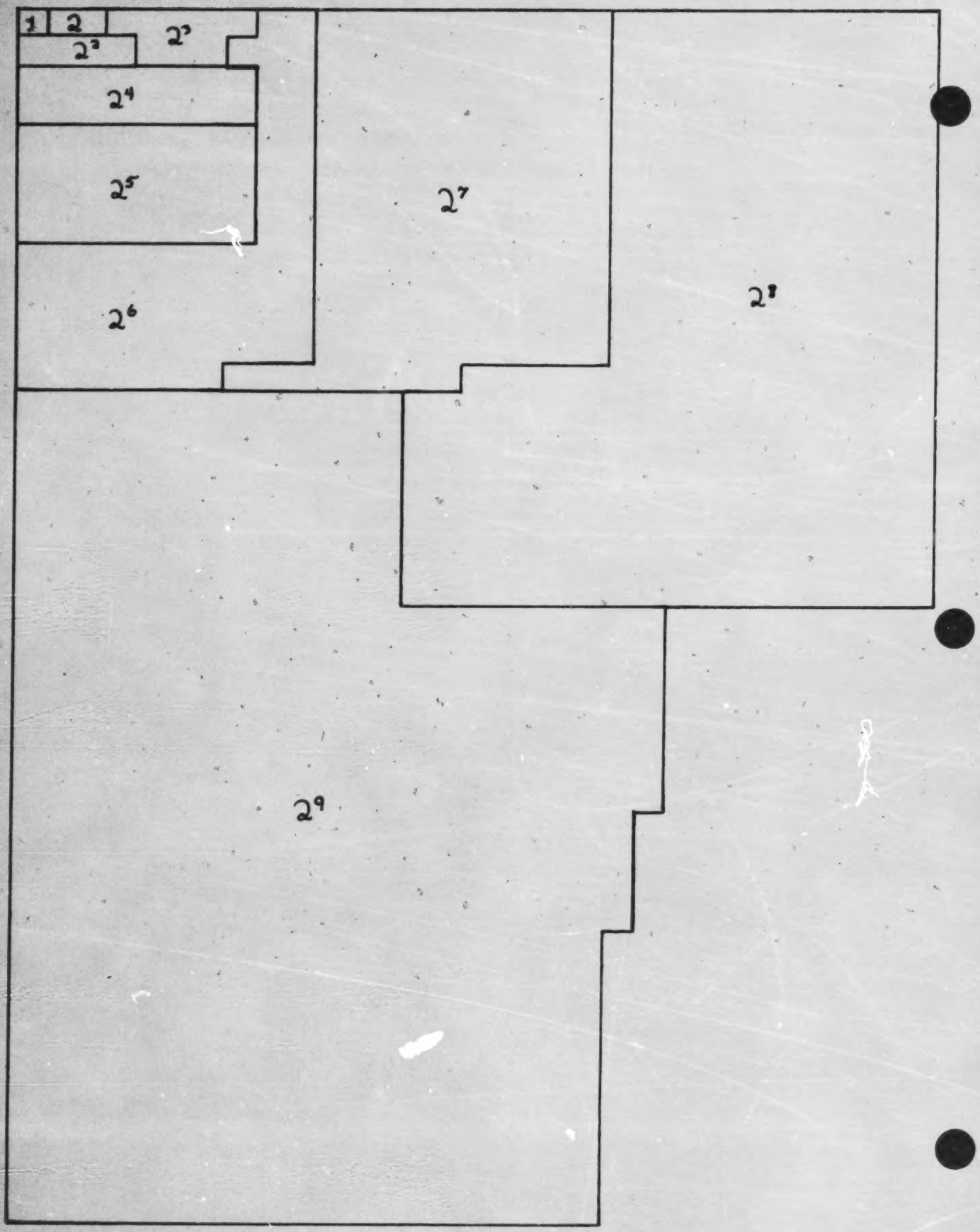
Questions:

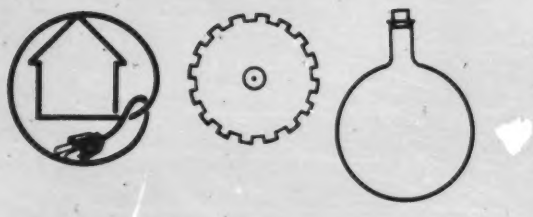
Ask what one would do in order to double the squares one more time. Get another sheet of paper?

Put Table A on the chalk board. Ask students to label their various colored areas with the exponent (power of 2) it represents. Draw attention to the fact that each successive doubling colors an area bigger than all the previous ones put together. This can be seen on Table A also . . . the previous "total colored" is always exceeded by the next doubling.

Now ask, "If we had continued to color only one square per minute instead of doubling every time, how much longer would the graph paper have lasted?"

The answer will be on the order of 1,200-1,500 minutes vs. the 8-10 minutes for the doubling pace (actual figures depend on the scale of the graph paper). Make the analogy to "steady-state" growth and/or use of resources vs. exponential growth or regular doubling of energy consumption, populations, human expectations of material goods.


1
2
2³
2⁴
2⁵
2⁶
2⁷
2⁸
2⁹



Thermodynamics: Some Basic Energy Limits

All forms of energy tend to change into heat. Quantitative measures of this trend are called the Laws of Thermodynamics. They are useful to many scientists and engineers. They are also important to every citizen because they help describe some of the energy constraints we may face in the future.

Most laws of physics are not time-bound. They apply to the past, the present, and the future. They permit explanation of past events as well as prediction of those to come. All the laws of motion, for example, are reversible in time.

But the Laws of Thermodynamics "smell more of their human origin" as physicist P.W. Bridgman wrote. They attempt to reconcile man's eagerness to identify "constants" with his actual practical experience with energy.

The First Law of Thermodynamics which states that energy cannot be created nor destroyed is often called the "Law of Conservation of Energy". It is based on the assumption that the amount of energy in the universe is fixed, that only appearances change.

The First Law of Thermodynamics arose out of human experiences with mechanical motion and the heat produced by the accompanying friction. Energy causes motion which meets resistance (of air, water, metal, other materials). This resistance is shown as heat.

Rolling auto tires, rotating drill bits, and falling water all get measurably warmer than their surroundings. Mechanical, electrical, or gravitational energy started those movements in the first place; work was done; and heat energy is a by-product of the motion. But can the heat be recaptured to do more work? Can it roll the car further, drive the bit deeper, lift water uphill again?

Experience shows that such energy recycling is not possible. Even though the quantity of energy involved may be constant, the quality of the energy has somehow been degraded. After conversion from one form to another, the energy available is no longer able to do as much work (or to produce as much power) as the original form could. So having plenty of energy and being able to account for all of it is <u>not enough</u>.

Energy sources are valued for their potential to yield power. That potential is reduced when energy is converted from one form to another. Most of the energy in food is used to keep a mammal warm and breathing; only a fraction is translated into work. Only about a third of coal's potential energy is realized in the production of electricity. Most of the rest is waste heat that does no work. This loss of potential to do work is called <u>entropy</u>, a negative quantity.

The Second Law of Thermodynamics is concerned with the degradation of energy and states that the entropy of the universe is constantly increasing. This second law is really a round-about way of expressing human frustration in encountering another "No-No" in direct practical experience. Man cannot create energy and man cannot keep energy flowing indefinitely to do his work. In other words, energy usage is a downhill process, time-bound and mortal like man himself.

A more general way of stating the Second Law of Thermodynamics is to say that all systems tend to approach a state of equilibrium. Heat naturally moves from a higher temperature area (heat source) to a lower temperature area (heat sink). It never spontaneously moves from a cooler area to a warmer one; that is, it never concentrates itself. Heat tends always to diffuse or spread out, just as a dye does in water. (See activity suggestion following.)

Demonstration:

Show students a large jar of tap water and a small bottle or dropper full of food coloring. Present them as examples of relatively organized, naturally concentrated materials.

Then add several drops of food coloring to the jar of water. Watch the dispersal of color until it is evenly distributed.

Questions:

1. Is the color as intense as it was originally? Why not?

2. How can the food coloring be concentrated again? (Boil off water; let water evaporate slowly.)

3. How can the water be restored to its original state? (Boil it off, catch and condense steam by chilling it.)

4. Do these methods require any energy use? (Yes--hot plate or Bunsen burner for boiling; warmth from room air or sunlight for evaporation.)

5. If we let the jar sit for a few weeks, will the dye settle out at the bottom or form a separate layer at the top? (No, but do it. Then compare the result to diffusion of heat energy into the environment by man's activities, heat we are unable to reclaim.)

Thermodynamics: Entropy - Down With Organization

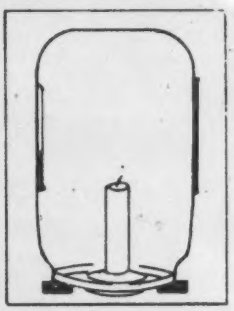
Entropy is a mathematical concept useful to scientists and engineers. It is becoming important in everyday life, too, as we recognize our dependencies on energy resources and attempt to account better for present and future energy usage. Awareness of limitations to the usefulness of energy in general, and most calculations of "net" energy available from particular conversions, grow out of an understanding of entropy.

The unavailability of energy for work, or entropy, is also considered a measure of disorder. Some analogies may be drawn to make this idea more tangible to students. Suggestions follow.

1. Measure the capacity (volume) of a clay flowerpot. (Use a measuring cup, graduated cylinder, or mathematical calculation according to your preferences. Or provide two identical flowerpots for comparison, an "experimental" and a "control" and some material--soil, BB shot, paper clips, rubber bands, etc.--for each to hold.)

   Then drop the pot so that it breaks as it hits the floor. Have students collect the pieces and calculate or measure carrying capacity of the shards. (The volume of soil, shot, etc. that fragments can carry is significantly less than that of the original pot or its unbroken twin. Its capacity to serve is greatly reduced; its entropy or lack of organization has increased.)

2. Demonstrate burning a small candle. Try setting a five-gallon jar upside down on one- to two-inch blocks, allowing air to enter. Center a candle in a non-flammable holder under the inverted jar. Tape a small thermometer onto the inside near the base of the jar and one onto the outside also. Let students record the temperature difference between thermometers as the candle burns low.



Questions:

a. Can you use this heat? Can you recapture the light or use it to do work? Can you reconstruct the candle from its vapors? Can you collect and reuse the carbon on the glass?

b. If you answered "yes" to any of the above, explain your answers. Does your method of recycling involve any additional energy input?

c. If you answered "no" to any of the above questions, what obstacles to success do you see?

d. If you do collect the carbon (soot) from the glass, will it burn and give more heat.

3. Put your house in order.

If left to themselves, natural systems tend to become more and more disorganized.

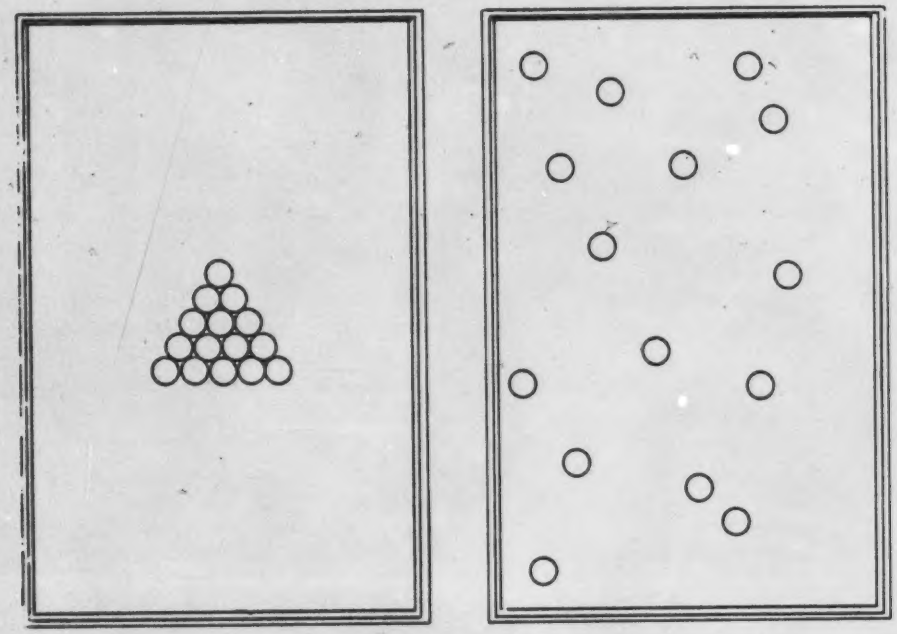
Use a common experience with houses as an illustration. If a house is not cleaned regularly and kept repaired, it tends to become messy. Some things get scattered, some break down. Neatness and order are reduced. Periodic expenditures of energy are required just to maintain the original condition of the house.

Another example to consider is the student himself or herself. Each person is a complex, highly specialized organization of parts that tends to come apart unless new energy is put into the system regularly. The fuel for maintaining order (health) is nutritious food.

4. Watch the action, folks!

This activity was adapted from Energy and Order by Mark Terry and Paul Witt (Friends of Earth, 1976, p. 3).

On a smooth, level floor or table, outline about a square yard with scrap pieces of 2 x 4's. Arrange 15 ping pong balls or rubber jacks' balls in the center of the square as shown. Have a student put energy into the system by hitting one of the corner balls with a ruler. Next, have students record how many additional energy inputs are needed to get all the balls back into their original positions. Allow use of the ruler or a wooden dowel only-no fingering. Ten to fifteen minutes should be enough time for discovering what is happening.



Discuss the results in terms of energy and disorganization.

Several individual set-ups could be made on a smaller scale. Use marbles instead of balls and 12" squares.

Or each student could do the activity individually, using a shoebox lid with lead shot for the balls and a pencil for their manipulation.

5. Mother Goose Hangs High (or "Energy, where are you when I need you?")

Remind the class of Humpty Dumpty's fate:

Humpty Dumpty sat on a wall,
Humpty Dumpty had a great fall.
All the King's horses and all the King's men
Couldn't put Humpty together again.

As he sat on the wall, Humpty Dumpty was a well-organized arrangement of his physical components. He also had potential energy due to his high position. When he fell, the dear egghead smashed into a disorderly splatter of liquid and solid ingredients.

Questions:

a. Think of Humpty Dumpty as an energy source. How is this event explained by the Laws of Thermodynamics? (All of his physical components lay on the ground. None were lost, as the First Law of Thermodynamics states. The arrangement of Humpty was very disorderly and unrecognizable, however. Also it resisted human efforts to restore its original state, in accord with the Second Law of Thermodynamics.)

b. What losses did Humpty Dumpty suffer? (He lost most of his useful energy or gained entropy. His "lifetime" was cut short. His value as a wall ornament, potential to do work, and concentration as a food source are all drastically reduced by his fall.)

c. After the fall, was Humpty Dumpty useless as an energy source? (He may not have been wholly useless. True, his energy of position is irretrievable and his scattered yolk and albumin may no longer be suitable for fueling large organisms like King's men. But some droplets of egg may be available to smaller organisms--ants, molds, bacteria, etc.--thus a fraction of its gross energy potential may be converted to work as a secondary step in the escalation of entropy.)

d. If he knew when he was going to fall, could Humpty-Dumpty have been more energy-efficient? (He might have pushed a paddle wheel, activated a lever, pulled a pulley-rope, aimed to land on the up-seat of a seesaw in order to propel another egg upward, etc. Consider a variety of simple machines--encourage students to brainstorm this and list suggestions on the board for elaboration or combinations.)

e. What is the message here for a throw-away society?

Thermodynamics: Heat Engines and the Second Law of Thermodynamics
(or "You Can't Break Even")*

Modern technology demands far more energy than can be supplied by men and beasts, even with the help of machines. Instead, it makes use of heat engines which consume fuel to produce heat and convert the heat into work.

It was learned through experiment that the potential energy in a fuel could never be completely converted into work. Some was always lost to the surroundings. We say "lost" only in the sense that this energy was no longer available to do work. What it did, instead, was to warm the environment.

Men had tried to invent heat engines that would convert all the energy of a fuel into work, but they always failed. It was found, instead, that a heat engine could be made to work only by the following two sets of processes:

a. Heat must be absorbed by the working parts from some hot source. The hot source is usually provided when some substance such as water or air (called the "working substance") is heated by the energy obtained from a fuel such as wood, coal, oil, or uranium.

b. Waste heat must be rejected to an external reservoir at a lower temperature. A heat engine cannot work any other way.

To help us gain further insight into this very fundamental concept, we are going to describe an imaginary situation--a problem--that can be solved only by doing work.

The problem is this: A landslide causes a large boulder to roll downhill. It comes to rest where it blocks the entrance to a cave home, and a primitive man wishes to remove the obstruction. What can he do?

He could perhaps get some of his family or friends to help him push it out of the way. Or he may have domesticated a large animal and could use it to do the work.

He would be even more likely to succeed if he could apply knowledge of simple machines. The lever, the wheel, the roller, the screw, the inclined plane (and later, the gear and the block and tackle) were all devices that could increase the force that a man or his animals could exert.

These three techniques--cooperation among peoples, use of animal power, and the application of machines--enabled man to build the pyramids of Egypt, the Great Wall of China, and the cities of Athens, Rome, and Carthage.

Adapted from Amos Turk, Ecology, Pollution, Environment, W.B. Saunders, Philadelphia, 1972, pp. 176-181. Used with permission of both the author and publisher.

But let's look at a more "modern" way of moving that boulder. Imagine that the cave man discovers that he can move it by wedging a bar of cooper between it and the cliff and then heating the bar with a flame. Because heated metal expands and the cliff is stationary, the boulder will move. He has constructed a basic heat engine. Now let us assume the following circumstances:

a. The man who wants to move the boulder has several copper bars, each ten meters long.

b. It is very awkward to build a fire under the copper bar between the boulder and the cliff, but it is convenient to have a fire nearby to heat the copper bars to the temperature of 100°C.

c. The outside temperature is 20°C.

d. The bar expands 0.17 mm for every degree of temperature rise.

The cave man, thinking he has discovered that hot copper bars can do work, heats one of his bars on the fire, wedges the hot bar between the cliff and the rock, then waits and watches. The bar cools and contracts, and no work is done.

This failure teaches him his first lesson in the design of heat engines: Work is done only by heating materials and allowing them to expand. Therefore, temperature differences rather than absolute temperatures are important.

Our cave man now decides to wedge a cold bar between the rock and the cliff and to bring hot bars to the cold one. He heats three bars to 100°C. He places the first bar on the cold one, as shown in the picture. The cold bar gets warmer and expands while the hot one cools and contracts. When both reach the same temperature, all heat transfer (and hence all work) stops. The temperature of the working bar rises from 20°C to 60°C while the temperature of the heating bar drops 40 degrees. The final temperature of both bars is 60°C.

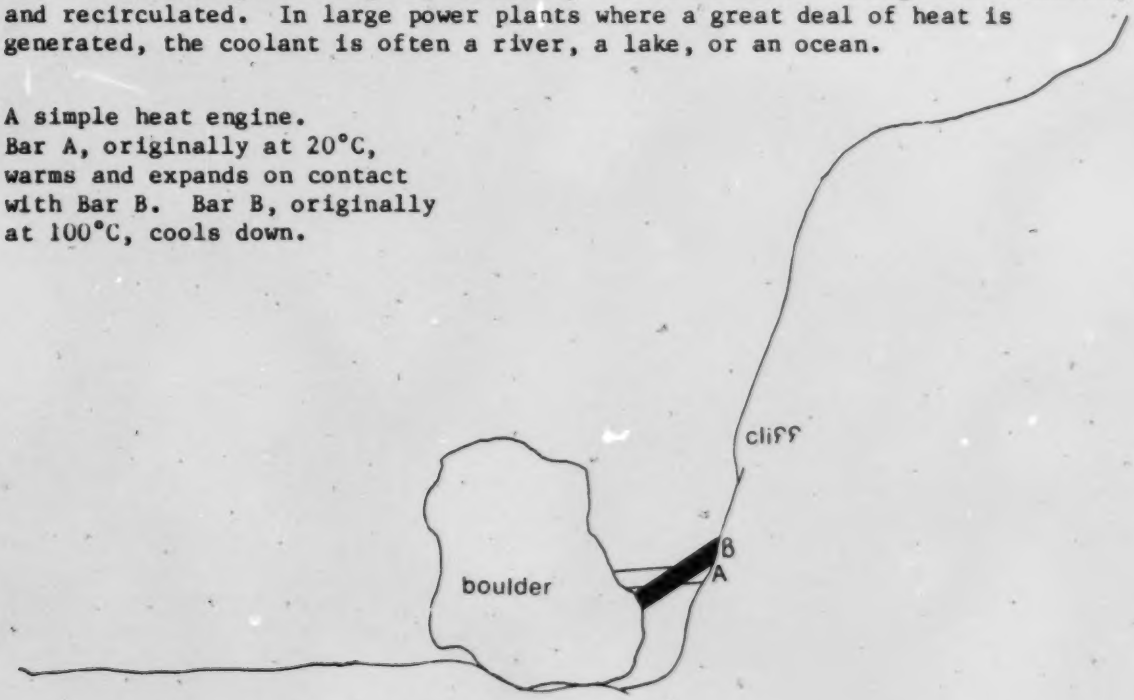
In order to move the rock further, the cave man places the second hot bar on top of the working bar and observes that the working bar warms from 60° to 80°C, and the new hot bar cools from 100° to 80°C. For every degree rise, the working bar expands 0.17 mm. Thus, the first time he heats the bar, the rock moves 6.8 mm. The second time it moves 3.4 mm. The last time it moves only 1.7 mm. Therefore the amount of work that can be extracted from a given quantity of heat depends on the temperature difference between the hot and the cold bars.

If the cave man were clever, he would not need to tolerate a diminished output of work after use of each successive hot bar. Instead, after each heating, he would cool his working bar back to 20°C in some nearby stream, replace it on the cliff (with an additional stone wedge to make it tight), and move the boulder a full 6.8 mm for every hot bar he used. He is now getting more benefit from the hot bars, but at some additional expense of human labor and energy and input of still another resource, the energy-exchanging water. He would be like modern man, then, because his advanced technology would have caused thermal pollution of his stream.

We use complicated heat engines today, but the relationships between work and heat have not changed. The working substance is generally a gas that expands to do work against a piston or the blade of a turbine. The gas cools as it does its work, but it cannot cool below the temperature of its surroundings. Therefore some provision must be made to remove waste heat from a heat engine.

In practice, cooling is generally accomplished either by blowing air past the engine or by running water over it. In most automobiles, for example, water is circulated through the engine, cooled by air as it flows through the radiator, and recirculated. In large power plants where a great deal of heat is generated, the coolant is often a river, a lake, or an ocean.

A simple heat engine.
Bar A, originally at 20°C, warms and expands on contact with Bar B. Bar B, originally at 100°C, cools down.



Questions:

1. What methods for moving the boulder are mentioned in the article?
2. What other ways can you suggest to more the boulder?
3. Which of the methods (mentioned in your previous answers) use the most energy?
4. Which would use the least energy but still move the boulder?
5. Which way would have the most environmental side-effects?
6. Which method of boulder removal would you try first if it was your problem? Give reasons for your answer.
7. Now assume that your youngest child is still behind the boulder, trapped in the cave without food or water. Would this affect your choice of method? Explain.

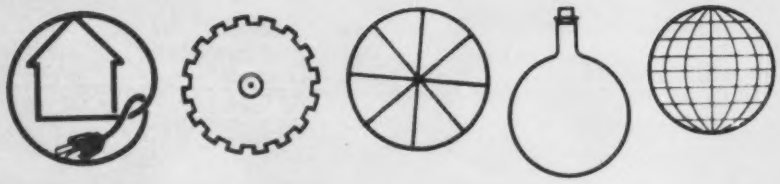
Teacher's Guide to Heat Engines

Dr. Turk's analogy of a boulder-moving device as a heat engine is an idealized example. You may want to point out that there would be heat losses of the bar to the air as the man carries it to the site, so the heated bar would no longer be 100°C when it reaches the working bar. Also more heat would be "lost" during the time required to reach equilibrium. Then when both bars are at equilibrium (some temperature less than the 80°C assumed possible if no losses occurred), they are temporarily warmer than their surroundings and will lose heat, over time, to the environment.

The cave-man example illustrates a key concept in energy education. Energy comes from some source, is used by living things, and is always less available for work afterwards. This is unlike Isaac Newton's claim that "For every action there is an equal and opposite reaction." Also, the idea of side-effects or "costs" of energy use is introduced. Everything we do affects something and/or someone else.

Hopefully, awareness that time is important will emerge from the questions. Some students may suggest that nature alone (freeze-thaw, action of lichens and mosses, chemical reactions with rainwater, etc.) will eventually move the boulder or disintegrate it. A person may use less energy by finding another cave for shelter, and letting nature take its course. Others, in a hurry, may suggest dynamite, jackhammers, powerful chemicals, bombs. The plight of the child also interjects a note of urgency that may make some change from a less- to a more-energy intensive solution in order to save time. However, the quickest solutions may also be life-threatening.

This should help highlight the impossibility of making wholly satisfactory choices. There are no "easy" answers. Every energy use has disadvantages as well as advantages.



Blowing in Some Cents

The Story:

"A windmill's effect on its owner is powerful and seductive. All you have to do is buy it, raise it, point it toward the wind, switch on the lights, and relax--a quid free of the quo, jubilee!

"Well, it isn't that easy. I heat my house with oil and cook with gas. My lights, television set and stereo, well pump, refrigerator, freezer, washer and dryer, a few power tools--these cost me slightly more or less than 700 kilowatt-hours per month. But to obtain the same amount of energy through wind power, assuming a windy enough location, would require a capital investment of $16,500."

--Geoffrey Wolff, Quest/78

Some Facts:

As of January 1, 1979, customers of New York's Consolidated Edison were paying $62.06 a month for 750 kwh of electricity. Hawaiians were charged $62.51 for the same amount. Washington Water Power Company (State of Washington) was charging least of all investor-owned power companies in the United States: $12.20 for 750 kwh of power. In Iowa, customers of Iowa-Illinois Gas and Electric paid $40.69 a month for this rate of use.

Falling water is a cheaper power source than fossil fuels. (Nuclear can be considered "fossil" in the literal sense of the root word, meaning "dug up.") But can windpower match the delivered cost of New York's electricity if Mr. Wolff's figures for installation of a windmill are correct?

Questions:

1. If Mr. Wolff lives in the state of New York, what does he pay per month for 750 kwh of electricity (at January 1, 1979 rate)? _____

2. How much is this per year? _____

3. Let your answer in question 2 represent the savings from use of a windmill that Mr. Wolff could expect in 1979. If he paid cash for his windmill, what percent of return on his capital does this represent?

   ($ saved _____ + $ invested _____) x 100% = _____

70

4. At this rate of return, how many years will he need to recoup his initial investment?

   Use the formula $\frac{70}{\%\ \text{return}}$ = years

5. If he does not buy a windmill, Mr. Wolff can invest his $16,500 at 9-10% in a special account at his local bank. Assuming his money earns only 9% simple interest, does it earn enough to pay his electric bills?

6. Based on your answers above, do you think that Mr. Wolff's decision was based on family economics?

7. What factors might change Wolff's decision?

8. What would be the advantages to owning your own windmill?

9. What would be the disadvantages?

Teacher's Guide to Blowing in Some Cents

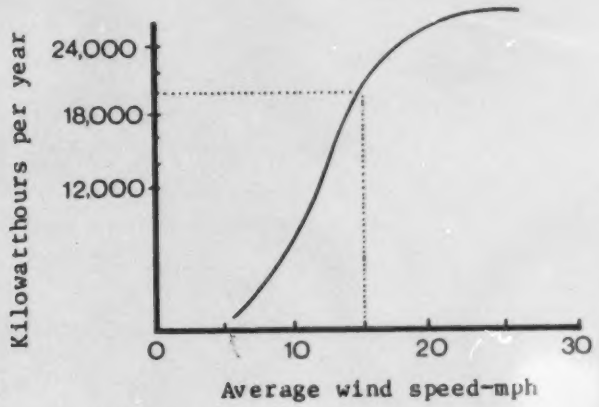
Although the energy source for a wind machine, moving air, is free, the equipment to convert that energy to useable form can be expensive. There are a number of methods for determining the cost of using wind. One is to estimate the cost of electrical generation by windmill using the following formula:

$$\$/kwh = \frac{(\text{capital cost})\ (\text{annual charge rate})}{\text{annual kwh production}}$$

The capital cost includes all expenses of the windmill including construction, delivery, and installation. This may be reduced by any available incentives such as the federal income tax credit.

The annual charge rate represents the interest, depreciation, taxes, operation, and maintenance as a percent of the capital cost. Although this varies widely with local circumstances, the American Wind Energy Association considers 18% as a typical annual charge.

The annual kilowatt hour production will vary from machine to machine and from site to site. However, manufacturers and distributors can usually provide a simple graph such as the one included here.



This graph can be used to make a gross estimate of the power that will be produced annually at various wind speeds. For example, if the machine represented by the graph were purchased for $16,000 completely installed, the cost of electrical generation at a site with 15 mph winds would be:

$$\$/kwh = \frac{(\$16{,}000)\ (.18)}{20{,}000} = \$.144 \text{ or } 14.4 \text{ cents/kwh}$$

If this windmill were in New York in 1979, its electrical generation at 14.4 cents/kwh is more expensive than the 8.3 cents/kwh charged by Consolidated Edison. However, commercial utility costs have increased rapidly and are likely to do so in the future. It is not possible to predict what average commercial cost/kwh will be over the life of the windmill. The cost/benefit ratio may change.

Also, this type of windmill is the most expensive kind. Windmills to pump irrigation water, or to warm water (see article in YE OLDE TIMES, SUN PRESS, and STAR GAZETTE included in this handbook), cost much less--$3,000 is the current quote for a conventional pumper--and are more likely to yield immediate economic benefits.

Answers Expected:

1. $62.06

2. $744.72

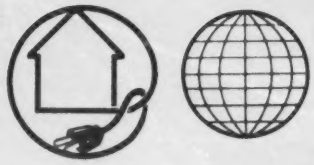
3. 4.5%

4. About 15.6 years

5. Yes, with dollars to spare. At 9%, his capital earns $1,485 vs. $744.72 in electric bills.

6. Yes, because the investment in a windmill shows a low return by today's standards.

7. Higher utility bills, lower earnings on his capital, lack of commercial electricity at any price, environmental threats by conventional power generation, desire for greater self-sufficiency, etc.



Energy and Home Site Development

Objective:

Students will observe how a developer begins a new area and how that area can be adapted for use of passive solar heating and for energy conservation.

Skills:

Observation, questioning, interviewing.

Concepts:

How housing developments are planned and conceived.

Adaptation of sites (lots) to the use of solar energy.

Directions:

Students should write out questions in advance to ask the developer. These can then be organized for his presentation. Questions should include some on solar energy usage.

Invite the developer to speak to the class. Have him bring plans, etc. used in making a development.

Discuss which lots would be best suited for solar energy.

Discuss how other lots could be made more adaptable to solar energy.

List all energy-conserving features considered in the placement of homes on the site. Ask the builder which features would have been "standard" ten years ago.

Extensions:

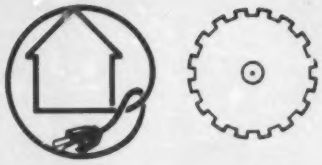
1. Take a trip to a development site.

2. Make follow-up reports on homes built in a new development and their uses of (or disregard for) natural solar heating.

Resources:

Developer(land), builder, lumberman, realtor, nurseryman, publications listed under CABIN FEVER IV.

This activity was developed by Iowa teachers participating in the DOE/UNI Home Economics Workshop, June 1979; Ella Jedlicka, Director.



Humdrum or Home Dome?

Objective:

Students will construct a geodesic dome from construction through the decorating process.

Skills Involved:

Critical analysis
Hand-eye coordination
Participation
Background in design

Concepts:

Exploration of alternative housing styles
Sharpening of design skills

Directions:

Using a geodesic dome kit or tinker toys, students will frame-up a geodesic dome. Plans will be designed for the placement of interior living centers. Samples of carpeting, paints, wall coverings, furnishings, etc. will be assembled and discussed by the students. A discussion will follow outlining problems faced during planning and construction.

Extensions:

1. Design a bulletin board display of building books or pictures of domes (photographs or magazine clippings).

2. Visit a geodesic dome or have a contractor visit your class.

3. Display the completed project at open house to make the public aware of alternative housing styles.

4. Compare heating bills of a geodesic dome home with a standard home of comparable square footage.

5. Discuss possible sites in your area suitable for a geodesic dome.

6. See if your town has building codes that would restrict geodesic domes.

7. Show people a picture of a geodesic dome and interview them about their impressions.

Resources:

Three-dimensional construction kits are available from a number of companies. The 1980 catalogue for Creative Publications (3977 East Bayshore Road, P.O. Box 10328, Palo Alto, CA 94303) lists the following:

#34170 Junior Kit, 220 pieces, $6.75
#34171 Apprentice Kit, 370 pieces, $10
#34172 Pre-Engineering Kit, 464 pieces, $13.95

Back issues of Better Homes and Gardens and other magazines.

Home owners and contractors.

This activity was developed by Iowa teachers participating in the DOE/UNI Home Economics Workshop, June 1979; Ella Jedlicka, Director.

Investigating Passive Solar Home Heating

Objective:

To identify five different types of residential passive solar heating.

Skills:

Gathering information
Computing
Critical thinking
Communicating

Concepts:

Solar energy can be used for space heating. Specific home design features aid solar heating.

Directions:

1. Discuss differences between active solar home heating and passive solar heating.

2. Present and discuss illustrations of passive solar heating.

   a. Direct gain (south windows)
   b. Thermal storage wall (window units, window shutters, drum wall)
   c. Thermal storage roof
   d. Sunspace (greenhouse)
   e. Convective loop

3. Research the U.S. energy pie -- what percentage is used for space heating?

4. Compute energy savings in quads or B.T.U.'s if half is solar.
   Compute the savings in dollars if half is solar.

Extensions:

Survey homes in the area (or the student's own) which use direct gain or could be adapted to solar heating by using one or more of the features listed above.

Research possible costs of the above retrofits and compute the pay-off over five to ten years.

Resources:

1. "Passive Solar Heating" (pamphlet), U.S. Department of Energy, Office of Conservation.

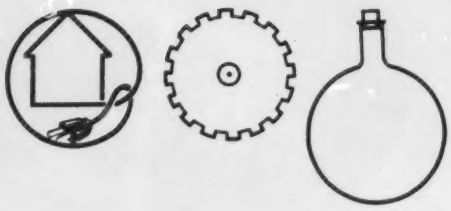
2. Fact Sheet #7 - Solar Energy for Heating and Cooling, U.S. DOE Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

3. "Passive Design Ideas for the Energy Conscious Architect," National Solar Heating and Cooling Information Center, PO Box 1607, Rockville, MD 20850 August, 1978 (pp. 40 through 48 especially).

4. "Solar Energy," U.S. DOE, address above.

5. Films/slides/videotapes from National Solar Heating and Cooling Information Center, address above.

This activity was developed by Iowa teachers participating in the DOE/UNI Home Economics Workshop, June, 1979; Ella Jedlicka, Director.



Mini-Drum Wall

Background:

Solar-heated buildings are subject to wide swings in temperature. They heat up rapidly during sunlit hours but cool off quickly after dark. To moderate the heat flow, mass storage has been incorporated into many passive solar structures.

To perform effectively, a storage system must incorporate significant weight (the "mass") of some material that absorbs heat slowly during exposure to light and then releases its stored heat slowly to the interior space at night. This thermal flywheel or time-lag effect is most important for keeping indoor temperatures lower by day and higher by night than in similar buildings without mass storage.

Some examples of heat storage systems incorporated into passive solar homes are Trombe walls; concrete slab floors over beds of rock or water bags; water-filled columns in or near the glazed south wall; adobe window seats; and drum walls.

Introduction:

Water is an especially valuable heat sponge. It is cheap. It is available everywhere that people live. It is reusable indefinitely. It has both a high specific heat and a high density; together these physical attributes give water the highest heat capacity of any substance at standard temperature and pressure. But its liquid form makes containers necessary.

Steve Baer of Corrales, NM, has built a prototype passive solar home using 55 gallon drums for mass storage of water. A horizontal stack of drums in a metal support frame stands behind glazed south walls fitted with insulating covers that are raised and lowered daily.

Other individual examples of mass storage systems based on water as the heat sponge are use of one-gallon to five-gallon plastic jugs or five and a half gallon sono-buoy cases massed together near a glazed southern exposure; columns made of steel culverts or fiberglass cylinders; roof ponds; and water-filled hoses embedded in a supporting wall of masonry.

Objective:

In the following activity, you will model a mini-drum wall, record its effect on heat flow within an enclosed space, and measure its heat storage capacity over a limited time.

Materials:

2 lb. coffee can with plastic lid
Two flat-sided, cheap styrofoam "cooler" containers designed to hold two 6-packs of canned pop are a convenient size, with interior dimensions about 17.5 cm x 25 cm x 29 cm (cost: $1.50 in 1980)
Heaviest plastic food wrap or clear polyethylene "storm window" sheeting
Four small thermometers (AS & E type) or three standard lab models
Masking tape
Black paint, brush, for shiny cans only
Aluminum foil: optional

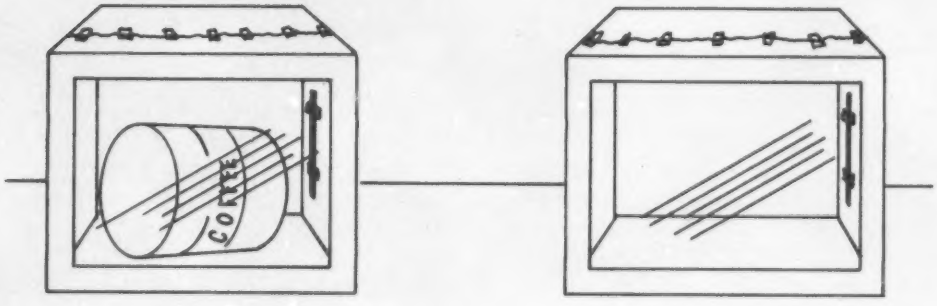
Directions:

If your coffee can is already stamped with a dark red or dark blue background color, no preparation is necessary. However, if it had a paper label and is now silvery-colored on the exterior, paint it flat black.

Measure out enough water to nearly fill the coffee can (Two quarts or two liters should do it). Record both the volume of water used and its temperature. If you have a small AS & E type thermometer, leave one in the "drum". Then secure the plastic lid.

Lay each styrofoam container lengthwise on its flat size, lid off. Tape a thermometer to the inside wall of each where it is out of direct sunlight but where it can be conveniently seen. Tape another thermometer to the outside rear of one of the containers to keep track of the ambient air temperature.

Lay the coffee can "drum" inside one of the styrofoam containers (label it "A"). Then cover the open side with clear plastic. Secure it across the edges with masking tape. Also cover the matching styrofoam container "B" with plastic.



Position both containers the same way, allowing sunlight to strike the plastic covers. (If you want to add an aluminum foil square as a reflector, laying it on the ground in front of each model, cut two identical squares.) Record air temperatures within both models and on the outside. Expose both models to the Sun for 30 minutes. Then record thermometer readings again, including the one in the drum. Subtract the first readings from the second ones to find the difference. Then estimate how much heat your mini-drum wall collected, following instructions on the data sheet.

Questions:

1. In your own words, describe the effect of the mini-drum wall on its air space.

2. How could the drum wall be improved to collect heat better?

3. How could the stored heat be made to last longer?

4. What materials (other than water) could have been used effectively in the drum to collect and store heat?

5. What materials would not effectively store heat?

6. Why was a "control" model used in this experiment?

7. How is a drum wall collector different from an "active" solar collector?

Resources:

Kroner, W. and Haviland, D. Passive Design Ideas for the Energy Conscious Consumer, free booklet from National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, MD 20850.

Magazines featuring contemporary homes. Consult Reader's Guide to Periodical Literature under topic headings: Conservation, Energy-Efficient Houses, Houses, Solar Architecture, Solar Energy.

Mazria, Edward. The Passive Solar Energy Book. Rodale Press: Emmaus, PA, 1979, $10.95.

Wright, David. Natural Solar Architecture, A Passive Primer. New York: Van Nostrand Reinhold Company, 1978, $7.95.

Extended Activities:

1. Use a third model, enclosing a water-filled shiny can the same size as the dark one. Follow the same procedure as with models "A" and "B". Compare results.

2. If time permits and/or you can do the testing over a weekend, expose the models for a longer period of time, two to eight hours, recording inside and

outside temperatures every hour. (Will it be necessary to check water temperature every time?) Then cover each unit tightly with its original styrofoam lid and let it sit undisturbed for a comparable length of time. Afterwards open each, quickly read thermometers and record results. Graph your data. Which is warmer? Why? Which container had more heat to begin with?

From your results, can you estimate how much stored warm water would be needed to keep a 20 ft. x 12 ft. x 8 ft. room comfortable overnight? If not, list the kinds of information you would need in order to make such an appraisal.

3. Draw a picture or outline a floor plan for a new home incorporating drum walls.

4. Write a list of design restrictions drumwalls impose and any other drawbacks to this method of heat storage. Make a second list of drumwall advantages.

5. Can you imagine portable solar heat storage, some kind of mass storage system that could be placed outdoors for full exposure to the sunshine yet be brought indoors (or its heat piped through) at night?

   If you can develop this idea, draw a picture or write some paragraphs describing your system. You may consult the librarian for reference suggestions on new heating systems for homes and other buildings. Can you find any examples now constructed and working?

6. Find out ways and means to keep drumwalls from rusting.

Name _____

Data Sheet: Mini-Drum Wall

Amount of water used: _____ ml or _____ g

_____ oz. or _____ lbs.

Time	Outside Temperature	Air "A" Temperature	Water "A" Temperature	Air "B" Temperature
Start:				
Finish:				
Difference:				

1. To figure heat gain in BTU's, multiply

   _____ (lbs. H_2O) x _____ (Difference °F) = _____ BTU's

2. For heat gain in calories, multiply

   _____ (g H_2O) x _____ (Difference °C) = _____ calories

3. What is the volume (interior space) of your styrofoam model?

   _____ (length) x _____ (width) x _____ (depth) = _____ (units^3)

4. What is the volume of the coffee can?

   _____ (length) x _____ (lid radius) x _____ (lid radius) x _____ (pi) = _____ (units^3)

5. Calculate what percentage of interior space is occupied by the mini-drum wall.

   _____ (Volume of can) ÷ _____ (Volume of model) x 100% = _____ %

Teacher's Guide to Mini Drum Wall

Objective:

This activity can provide students with an opportunity to see how a mass storage system may moderate heat gain and heat loss in a building, to notice differences in heat capacity of some materials, and provide practice in quantifying heat.

Time Required:

At least two 50-minute class periods are needed: one for introduction to thermal storage ideas and for preparation of the materials; one for data collection and calculations. Questions and extended activities (optional) may be done as outside assignments or during class time.

Advance Preparation--Materials:

Collect styrofoam boxes, clear plastic sheeting, coffee cans. Two pound cans are suggested as an effective match for the cooler size specified. You could use smaller cans but more of them, or you could select another size of styrofoam cooler. If you do, try to maintain a ratio of at least one volume of water to every ten volumes of air.

Get flat black paint and brushes if necessary. Cans that are blue or red color-painted metal need no extra paint.

Aluminum foil (optional, but it does boost the amount of sunlight entering the enclosure) should be on hand.

Hand calculators are desirable, optional time-savers on the volume calculations in particular.

Plastic jugs of tap water should be set aside for filling drum walls. Set them out a day ahead of time so that the water temperature is at equilibrium with the ambient air and any excessive aeration escapes. Chill a 16 oz. bottle of pop the day before the experiment.

Procedural Notes:

Students measure temperature and mass of the material, but must calculate heat gain by multiplying those two variables. Either BTU's or calories can be conveniently used as energy units. BTU's, based on the Fahrenheit scale, are commonly quoted when the subject is energy consumption of the whole country or the heating capacity of a furnace. However, calories may be a more familiar term to diet-conscious students. Remind them that calories, based on the Celsius temperature scale, are 1,000 times smaller than a kilocalorie or food calorie.

Give students advance practice calculating BTU's. Use the half-hour waiting time that the models sit in the Sun. Heat up a beaker of water for a few minutes. BTU's gained = pounds of water x ($°F_2 - °F_1$) or calories gained = grams of water x ($°C_2 - °C_1$). Also remove a 16 oz. bottle of cold pop from the refrigerator, immediately record the temperature of the pop, and then let it warm up (may be speeded somewhat by warm hands clutching the bottle). Again calculate BTU's and/or calories.

It is not necessary to actually weigh the water in any of these activities. Careful measurement of volume is sufficient because water's weight/volume relationship is predictable. Under normal conditions, the mass of 1 ml of water is 1 g and the mass of 16 fl. oz. of water is 1 pd.

Results:

Air and water in the drum wall model will appear to heat more slowly than does the all-air model where temperature rises rapidly. If time permits measurement of the cooling rate, the drum wall model will also cool more slowly. The difference in response to heat by various materials is noteworthy.

Some students may prefer to use an empty (air-filled) can for the control "B". If they do, the air space will heat even more rapidly at first, but it will cool very rapidly also.

Drum water and air within the same enclosure will show the same temperature throughout. Equilibrium is maintained between the collector can and its immediate surroundings. So taking a separate record of the water temperature inside the drum, especially during an extended activity where data is collected over several hours, is unnecessary. Because of its much greater mass, the water holds much more heat at any given temperature than air does. But the thermometers do not measure total heat; they measure average heat only.

Sample figures for an actual test follow:

	Time/Temperature (degrees Fahrenheit)						
"Drumwall" models	1:00 pm	1:30	2:00	3:15	3:45	4:30	5:00
1. Black can, air-filled	66	114	112	100	94	82	78
2. Black can, water-filled	66	74	80	88	92	94	90
3. Black can, paraffin-filled	66	90	90	92	90	88	84
4. Outside air	66	66	66	66	66	66	65

If you are curious about the relative heat capacity of air and water compared to other materials, the following data is interesting.

Specific Heat and Heat Capacity of Selected Materials*

Material	Specific Heat (BTU/lb. per °F)	Density (lbs./ft.^{3})	Heat Capacity (BTU/ft.^{3} per °F)
Air	0.24	0.075	0.018
Brick	0.20	123.	25.
Concrete	0.156	144.	22.
Oak Wood	0.57	47.	26.8
Polyurethane (Expanded)	0.38	1.5	0.57
Steel	0.12	489.	59.
Water	1.0	62.4	62.4
Wool Fabric	0.32	6.9	2.2

Data from American Society of Heating, Refrigerating, and Air Conditioning Engineers, ASHRAE Handbook of Fundamentals, New York: ASHRAE, 1972.

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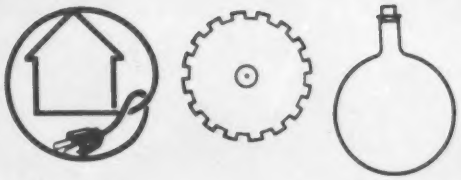


A Simple Solar Oven

Objective:

To demonstrate the use of direct solar energy to warm air in an enclosed space and to cook foods.

Background:

Cooking with the Sun is a way to show that light energy can become useful heat energy. But time, energy, and materials must be properly invested in order to make use of "free" solar energy. This incoming energy is spread out, not concentrated. And its rays seem to change direction as our Spaceship Earth circles the Sun. Still, solar can be used effectively for many jobs, including slow-cooking of meat and potatoes; heating houses; and heating water. This model oven will give you chances to do some solar heating and solar cooking on the next sunny day.

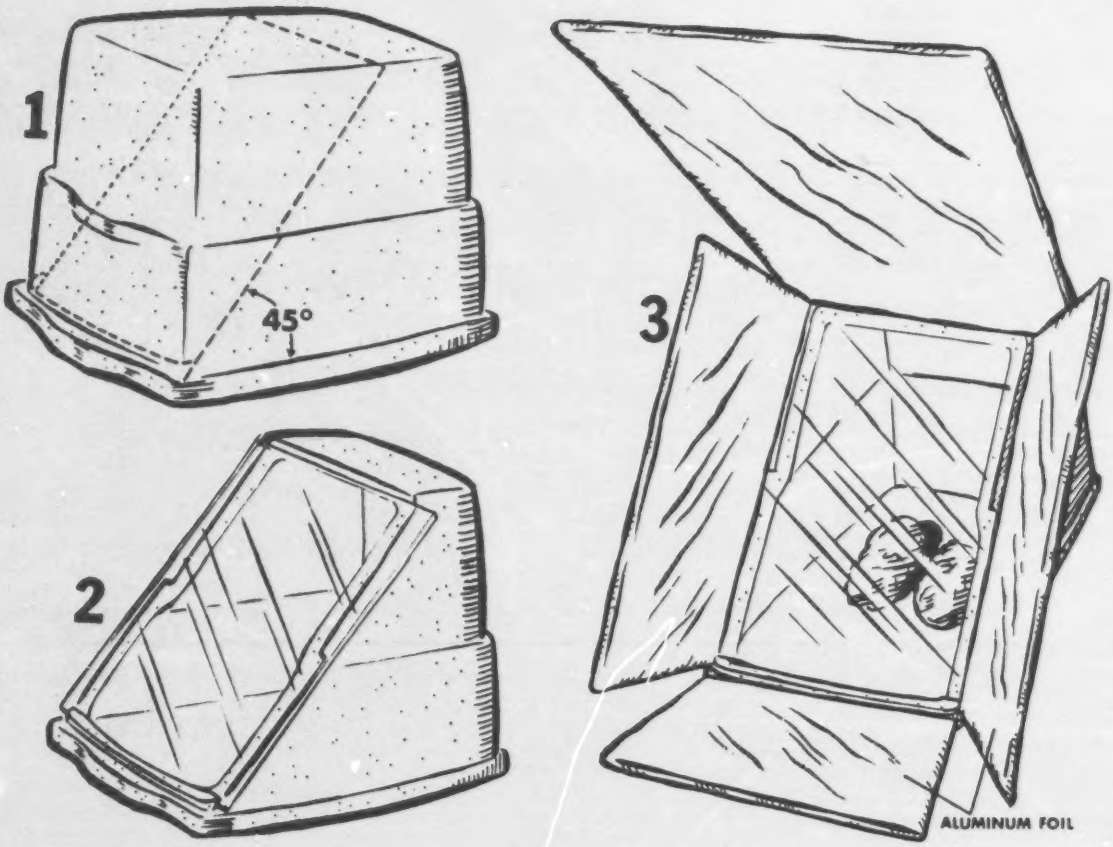
Materials:

Rectangular styrofoam cooler with well-fit lid
Oven thermometer
Duct tape and scissors
Jigsaw, electric knife or craft knife
Double-strength glass pre-cut to fit over your cooler opening
Asbestos sheeting
Aluminum broiler foil
Protractor, ballpoint pen
Rubber cement
Cardboard, corrugated boxes, sheet aluminum or any other reflector material available

Directions:

Set the cooler upside down on its lid. Using the protractor and ballpoint pen, mark the 45° diagonal from the bottom "lid" edge upward, as in diagram 1.

Cut as indicated by the dotted line, diagram 1, leaving slots for the glass window to rest in. Line the inside with asbestos sheeting first and then aluminum broiler foil. Cement the lining in place. You may also paint the inside foil lining with high temperature black barbecue finish paint.



Measure the opening for glass and buy a piece that will cover it and the styrofoam edges completely (diagram 2). Tape the glass securely in place and cover all edges with aluminized duct tape.

Make reflectors from cardboard or pieces or corrugated boxes covered with aluminum foil. Hinge two of them and attach with duct tape to the sides of the oven. Support the backs with hanger wire if necessary. Lay one reflector on the ground in front of the oven and angle another one over the top. (See diagram 3.) You can see spots of light on the glass when the foiled panels are positioned most effectively.

Position your solar oven outdoors with the glass directly facing the Sun. You have the correct position when the shadow of the oven lies directly behind it, not more to one side than the other. Every 15-20 minutes you will have to move the oven slightly to keep it oriented to the Sun.

Lift your oven off its base (formerly the lid of the cooler) to put in an oven thermometer and whatever food you want to bake slowly. Potatoes are shown in the diagram. Cookies can be baked on a cookie sheet or pie tin.

Questions:

1. What was the highest temperature recorded in your oven?

2. How could you improve efficiency of the oven?

3. Can you expect to get the same oven temperature almost any day?

4. What advantages are there to using portable solar ovens?

5. What disadvantages or limitations to the use of solar ovens have you thought about?

6. If you had only a solar oven for cooking, how would your diet change?

7. List as many consequences of widespread use of solar ovens as you can foresee.

Extensions:

You may also want to use your "oven" (with or without reflectors) as a model of a passive solar home. Put the thermometer inside and test its heat gain outdoors on a cool day when home or school is made comfortable by use of its furnace or boiler.

Does a ground reflector help? Is the angle of the glass an advantage or disadvantage? (Change it by propping the oven higher or lower on one end.)

What effect does shading have on heat gain? (Make a cardboard "roof" extension to shelter the glass.)

Keep in mind that a house does not ordinarily move on its site (although innovative pod-like homes that turn on a pedestal have been built). Therefore storage of some of the heat gained by your "house-oven" during peak suntime for release at night is important to any passive solar design.

After you have recorded the temperature changes in your empty model over a period of several consecutive hours--from noon to sunset, for example--change the conditions the next day by adding one of the following: some rocks, a can of water, a can of paraffin, or a jar of eutectic salts to the interior of your construction. Record the temperature changes during the same hours as before. Compare results.

Or, if several classmates have made identical models, you may be able to test various materials simultaneously. Decide how much material each should use to keep amounts comparable. Then record temperature changes over several hours.

Which material stored heat best? Which material would be easiest to incorporate into a new house plan?

Try to find information on existing buildings using any one of the heat storage materials you tested and write a description of it to present in class.

Teacher's Guide to A Simple Solar Oven

Cooking with the Sun has been one of the more popular projects attempted by solar enthusiasts. Hot dog cookers with a spit and curved reflector are easy to make. Umbrellas lined with mylar have been used to focus solar heat on a teakettle or rice pot. Curved reflectors made of aluminum also can help concentrate light onto food enclosed in black cans or glass-windowed boxes. Fresnel lenses have been used to produce intense heat, and oven plans using one are available for $.75 from Edmund Scientific Co., 1888 Edscorp Building, Barrington, NJ, 08007.

A durable oven made of sheet aluminum and plywood is described in detail, with construction diagrams, in Practical Sun Power by Rankins & Wilson, from Lorien House (publisher), P.O. Box 1112, Black Mountain, NC, 28711, for approximately $4. This model would be appropriate for industrial arts students to build and would last longer than the model described here. However, it would require a greater initial investment of time and materials to complete it.

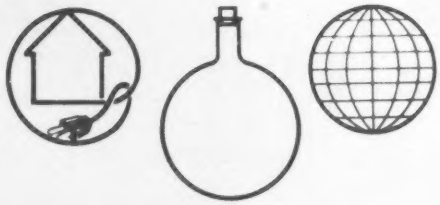
The styrofoam box model suggested here is inexpensive to construct and can be used as a "model house" as well as a solar oven (with minor modifications). Turning the "lid" into a "base" eliminates some cutting and fitting. Most materials are readily available and can be worked without special tools. To prevent out-gassing of the styrofoam into the oven, it is important to cover the styrofoam with asbestos sheeting (comes in 24" wide rolls at the hardware store and is very inexpensive--$.25 worth should line an oven this size). This, in turn, is covered with aluminum foil. Less critical is the decision whether or not to paint the interior black. If you do, use a black barbecue finish made to stand heat. There was no noticeable difference in temperatures recorded between bright foil-lined and painted-foil-lined models that this author built. Differences between single and double panes of glass were also small. Double-strength glass is recommended, however, as less likely to crack under heat. When the oven was empty (full of air, as in a house) then a double-paned glass model heated 10-15°F hotter than a single-paned one. When water was to be heated (as in a rice casserole, or potatoes or meat which are three-fourths water themselves), the single-paned model cooked faster.

Simple flat aluminum foil reflectors, on the other hand, improved performance considerably, raising the interior temperature of a double-glazed model by 40°F in 15 minutes on a September afternoon. Mirrors or curved aluminum reflectors may improve performance even more.

The main problem with the reflectors as described is wind. Unless reflectors are weighty, every breeze can change their position and reduce their effectiveness. Wind chills the oven, too, suggesting the need for careful sealing and more insulation if the oven is to be used often.

One of the main objections to solar cooking in fuel-short Third World countries is that the ovens work best around noon. This is not the traditional time for a cooked meal. Daylight hours are for working, marketing, schooling and any other away-from-home activities. Evening is the time for socializing over dinner, but sunlight is not available then. . . . Solar ovens also need adjustment (about every 20 minutes at our latitude) or turning to keep the glass front in direct line with the incoming sunlight.

The low heat (280°-300°) developed in the model oven described is suitable for baking potatoes (2-3 hours, depending on size) or slow-roasting meat or heating casserole dishes. Cookie dough would be a good choice for an edible project that can be baked during class time.



Energy and Standard of Living

A Participative Demonstration

Americans are justifiably proud of having achieved a "high standard of living" and treasure a certain "quality of life." But a rapid rate of using mineral wealth may make us too dependent on certain resources that are limited in supply. The following simulation may suggest effects of depletion of fuel reserves on the standard of living to which we are accustomed. The primary objective is to show how closely related are the commonly accepted elements of comfortable living and the availability of underground petrochemical reserves.

Materials:

About 100 yards of colored string, cord, button thread, fishing line, or yarn
About 100 yards of white or natural string or cord or button thread (assorted scraps can be used, so long as there are two distinct types or colors available)
Paper for large name-tags, and pins to attach them
Marking pens

Procedure:

Ask each student to help define a "high standard of living" by making a short, personal list of the things (products, services) that he associates with a high standard of living. Then ask each student in turn to read off one of those items, trying not to repeat those previously mentioned. Write the students' suggestions for factors in a high standard of living on the chalkboard. Some likely suggestions will be "nice clothes, easy transportation, appliances, comfortable house, swimming pool, long vacations, trips, sports, television, radio, restaurants, sanitary services, medical care, gardens," etc.

After each person has contributed at least once, ask the class for any additions or combinations. When responses slow down, then consolidate items on the master list until the number of necessities for good living is the same as that of the people in the classroom.

Assign each student the "role" of a particular item (from the class list) necessary for a high standard of living. Take for yourself one saying "energy" or "fossil fuels" or "petroleum" or whatever equivalent was suggested by the students. Each person should label a large name tag (piece of paper) with his role-title and pin it on his clothing.

Ask students to arrange themselves in a circle and to use lengths of white string to connect themselves with any and all other elements of the good life on which they depend. Put yourself in the middle and ask students to connect to you a length of colored string if the product or service they represent requires your energy input. A rather complex web should emerge.

Next ask everyone to imagine that a serious shortage of fossil fuels occurs. Simulate the results by first removing all white connections between components that also have a colored string (dependency on fossil fuels). Leave the other white threads intact. Second, remove all colored strings. (Say that the fuel supply is so limited that only emergency needs can be met.) Have students with no connecting strings left leave the ring.

The resultant two-stage simplification of the web is dramatic. Make comparisons to social and ecological dependencies that involve us all.

Questions:

1. What hardships would the "simple life" of the remaining web (without abundant fossil fuels) impose on people?

2. What would be the advantages of a simpler life, less dependent on energy?

3. Would widespread solar power or fusion energy possibly rebuild the web entirely (based on some product and service items originally specified) if all fossil fuels were gone?

4. Can you describe a "high standard of living" without including the need for goods or services provided by fuels dug up from the Earth's surface? What would its basic elements be?

Energy and Transportation
(A Value Dimension)

Background:

Personal transportation in the United States consumes more fuel than does total household usage. In other words, a typical American spends more energy getting away from the house than in maintaining a comfortable home.

Sometimes the reason is "urban sprawl." People move away from the central city, keeping the most desirable places to live and the places to work widely separated. Traveling for two hours each way to work and back is even seen as a great part of the American dream according to a Wall Street Journal article (May 8, 1979) on commuters. One Californian who spends four hours daily on the road between home and work explains, "I work where I want to work and live where I want to live."

Americans drive farther and faster than any other people in the world. Not everyone thinks that Americans' travel record is just an expression of great personal freedom, however. Travel can educate, can introduce one to a greater variety of people and experiences, can refresh and renew both the traveler and his acquaintances along the way. But travel can also be correlated to restlessness, lack of planning, and escapism.

There is no single description for traveling and its effects on which Americans would agree. Many have been suggested. Some of them are listed below.

Travelers are . . .
- nomadic
- irresponsible
- rootless
- wasteful
- inquisitive
- hyperactive
- expansive
- cheerful
- disruptive
- careless
- litterers
- polluters
- playful
- nervous

Effects of travel (or lack of it) are . . .
- duplications
- friendliness
- hospitality
- insularity
- nostalgia
- complacency
- suspicion
- anomie
- conservatism
- generosity
- thrift
- stability
- work
- relaxation

Activity:

1. Choose three words (from the lists above) that you associate with personal transportation, words that either (a) express your feelings about constant travel or (b) are unfamiliar and so are a challenge to define and relate to a major source of energy consumption.

2. Write three sentences, one for each word chosen, using that word appropriately to describe your impressions of extensive use of personal cars.

3. Write another three or four sentences describing a day in your life when you transported yourself on foot only. Use any list words that seem appropriate.

4. Consider the fact that Americans spend more fuel getting away from home than they do in maintaining its comforts. What do we do away from home that cannot be (or is not usually) done there?

5. Would the items listed in Question 4 be the same for people in India? in Sweden?

Energy in Manufacturing--I

An electric carving knife takes twenty times as much energy to manufacture as it will use in a year. The chart shown below gives this same ratio for some other common household items. It tells how much energy it takes to manufacture a product compared to how much energy the product uses in a year.

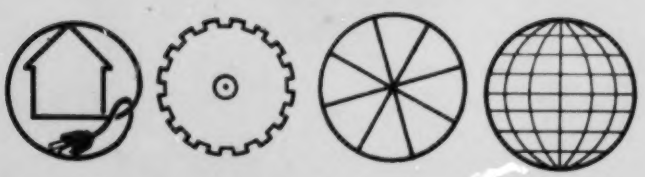
For many power-driven gadgets, the main energy expense is in their production, sales, service and ultimate disposal; and not in their use. A good deal of the energy capital invested in a household is not used very well. People often buy expensive and complicated appliances and then use them only occasionally.

	Ratio: $\frac{\text{Energy to Manufacture}}{\text{Energy to Run for One Year}}$
electric knife	20
electric can opener	17
garage door opener	50
garbage disposal	30
power mower	3
roto-tiller	25
shredder	20
snow-blower	25
trash compactor	20

From Household Energy Game, University of Wisconsin, Sea Grant College Program, Madison, WI 53706.

Questions:

1. What are the alternatives to using each of the household appliances mentioned above?
2. What are the other costs (besides energy) of the appliances mentioned--economic, environmental, social?
3. What are the benefits of these appliances?
4. Which appliances can you most easily live without?
5. Which can possibly be rented or shared with neighbors for more efficient use?



Energy in Manufacturing--II

Nearly all common materials require some processing before they are ready for use in standard form. Processing requires energy. Finished products that can be reused many times (or used over a long period of time) make more efficient use of this "energy of formation" than do those whose useful life is very short.

Paperboard, for one example, costs more than 100 times as much energy to manufacture, pound for pound, as does wood. (See chart following, Amount of Energy Required to Process Some Common Materials.) More boxes per ton can be made of paperboard, however, and less human labor is required to finish them than to put together wooden ones. Still, if each kind of box is used only once (as fruit crates are), paperboard cartons cost more energy than wooden ones. Polystyrene baskets (for berries, tomatoes) cost even more energy to make, petroleum itself being the basic stock for its chemical make-up. (See the same chart.) Can you see why some plastic containers may be the "collectibles" or antiques of the future?

Another factor to consider in calculating energy expense for materials is time of their useful lives. How long will this material last in finished form? Compare a pound of paper plates to a ceramic one or a pair of plastic ones. What is the useful life of the several paper ones vs. one ceramic one? vs. two plastic ones? To carry the energy cost analysis further, estimate how much energy will be required for maintenance of the glass and the plastic plates vs. how much energy will be required for disposal of the paper ones over the same time span. The high energy cost of a throw-away society should become obvious.

If you are clothes-conscious, then polyster, acetate, acrylic, and spandex may be familiar words. These fibers are all made from chemicals derived from fossil fuels. Much of the twenty-five billion square yards of fabric produced in the U.S. annually is based on these synthetic fibers which are very energy-expensive compared to cotton and wool. Do they provide longer wearing life to justify their higher initial energy investment? Or are they also luxuries of the Hydrocarbon Age that will become relics of 20th Century America?

Suggested Activity:

1. Have students use mail-order catalogs, and hardware and plumbing suppliers' ads, or have them phone local businesses to get the following prices:

   a. fiberboard shelves, chests, or room dividers vs. wooden ones;

   b. polyester shirts vs. all cotton shirts;

   c. copper vs. plastic pipe;

   d. paper, glass, and plastic plates;

   e. plastic vs. wooden toothpicks;

   f. plastic vs. straw brooms;

   g. steel, aluminum, and copper wire.

2. Estimate the length of useful life for each of the above items and compare it to cost . . . how many dollars/year is it likely to cost?

3. Check the energy investment each item represents on the chart. Did the more expensive items require more fossil fuel input to process their basic material? If not, why are they relatively expensive? Which items on your list would you expect to become most expensive as fuel prices rise?

4. Look at the chart again. When expensive energy becomes a way of life, which industries may have the most difficult time keeping costs down? (Keep in mind that the weight of the product is related to the energy cost on this chart. Miniaturization, where possible, is a viable strategy.)

Amount of Energy Required to
Process Some Common Materials

Material	Energy Input BTU x 10^6/ton
Crushed stone	0.1
Wood	0.3
Brick	6.9
Cement	12.4
Flat glass	18.1
Iron casting	25.0
Lead	31.1
Paperboard	36.4
Paper	40.6
Steel casting	46.7
Steel: carbon, cold-rolled	52.7
Aluminum: rolled, forged, cast	75.0
Zinc: rolled	79.2
Copper: wire	106.2
Copper: rolled	128.0
Nickel	374.7
Tin	469.3
Polystyrene (a plastic)	22,600.0

Data for this table is from Patterns of Energy Consumption in the United States, U.S. Office of Science and Technology, January 1972.

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How Now, Dry Cow!

Bringing food to our table means using energy over and over again. How much energy is consumed in producing and delivering any one commodity varies greatly. Each step in the processing chain costs energy, and as the cost of energy has grown to be appreciable, that expense is becoming reflected in grocery store prices.

The energy in an essential food like milk came from the sun. It stimulated the growth of plant fodder for the cow who transformed and concentrated some of that stored energy into milk. Getting that milk from the cow to your kitchen usually involves much more energy, amounts depending on the route followed.

Milk can be bought in several forms. Fresh milk is usually packaged in waxed paper cartons or in plastic jugs. Evaporated milk is offered in cans. Dried skim milk is usually packaged in foil-lined paper boxes. How much does each of these types of container hold? How many containers are necessary per gallon of milk? Which kinds "cost" the most energy? (See the accompanying chart: Amount of Energy Required to Process Some Common Materials)

Processing each form of milk (fresh, evaporated, dried) requires energy. All milk is pasteurized, a process requiring heat to kill dangerous bacteria. Evaporated milk is not only pasteurized but also is heated further until half of its water content is gone; then it is heat-sealed into cans. Drying milk to powder or granules also requires considerable energy, but the loss of water means loss of weight, so packaging and transportation costs are reduced. Loss of water also stops common bacteria from living on the milk, so energy-expensive storage (refrigeration) is unnecessary. Fresh milk must be refrigerated constantly.

Transportation of milk costs additional dollars and is often proportional to weight. As energy prices soar, the processing, packaging, storing, and transporting costs of marketing milk will also increase.

Activity:

Check prices of canned, fresh, and dried milk at your local grocery. Be sure to note unit size and weight as well as price. Fill in the following data table:

Milk Type	Price	Unit Size	Unit Weight	Equivivalent fluid volume	Price/ Gallon
fresh					
canned					
dry					

Questions:

1. Which type of processed milk cost most?
2. What were the energy inputs contributing to this cost?
3. Which type of milk cost least?
4. Give at least one reason why this type is less expensive.
5. List an advantage and a disadvantage of each of the processed milks.
6. How could some of the energy consumed in processing milk be provided directly by the sun? Try to suggest at least one possibility.

To bring canned milk to the equivalent of fresh, multiply by 2. To bring dried skim milk to the equivalent of fresh, multiply by 10. (4 lbs. dry milk + 36 lbs. water = 40 lbs. or 5 gallons of fluid milk.)

Amount of Energy Required to Process Some Common Materials

Material	Energy Input, BTU x 10^6/ton
Crushed stone	0.1
Wood	0.3
Brick	6.9
Cement	12.4
Flat glass	18.1
Iron casting	25.0
Lead	31.1
Paperboard	36.4
Paper	40.6
Steel casting	46.7
Steel: carbon, cold-rolled	52.7
Aluminum: rolled, forged, cast	75.0
Zinc: rolled	79.2
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Life Styles and Energy Use - I

Objective:

To express the relationship of energy usage to one's life style.

Directions:

Assign students a research project examining the life style of a particular culture and relate the differences in their energy consumption to the student's own life style. The Fox Fire I, II, III, IV series on Appalachian folkways are good resources. Other sources certainly may be used also.

From these books or others, students could explore the following areas:

1. Methods of housing construction, lighting, and heating.
2. Methods of food preservation.
3. Methods of meal preparation and equipment used.
4. Forms of entertainment.
5. Textile and clothing construction.
6. Methods of farming and food production.
7. Methods of transportation and communication.

Along with a written report, or in place of it, students could present their report orally, give demonstrations comparing the differences and relating life style to the usage of energy, or construct models showing how other cultures do the above.

This activity was developed during a DOE-sponsored workshop directed by Ella Jedlicka at U.N.I., Cedar Falls, IA, 1978. It has since been classroom-tested by Jamie Adair, Griswold Community School District, Griswold, IA.

Life Styles and Energy Use - II

Background:

Many ways of arranging for daily needs are possible in the United States. Diversity has always been counted as a positive quality in our culture. An example is the difference in lifestyles between those who deliberately choose to become more self-reliant and those who take great pride in using and accumulating manufactured comforts. Motives vary greatly, and so does energy usage due to differences in lifestyles. The four case histories that follow are meant to emphasize some of these differences.

Procedure:

Duplicate the case histories for student use. Give at least two of them to each student. Have them read the stories and make a list of fuel-dependent equipment each subject probably uses. Then divide the class into groups of four to six, asking each to compare lists and to agree on a combined one for each case. Then discuss the implications of these lists.

Questions:

1. How will energy shortages affect the people you read about? Who will be affected most? What changes will each have to make?

2. How much time do the Bielers spend in direct basic maintenance of their family? How does this compare to your family's use of time?

3. Why do most people prefer to work at some specialty in order to pay others to provide essential services?

4. Why is greater self-reliance appealing to some people?

5. Which case history describes a lifestyle least likely to harm the environment?

6. Which case history describes the most energy-intensive lifestyle?

7. Which case history shows greatest awareness of need to cooperate with others?

Related Activities for Students:

Write another energy case history, describing your own way of life as you'd like it to be ten years from now.

Write an energy case history of a family in Mexico, Nigeria, New Zealand, Labrador or any other location where energy choices and energy needs are likely to be different from yours.

Read the article: "Voluntary Simplicity: Life-style of the Future?", by Duane S. Elgin and Arnold Mitchell, The Futurist, August, 1977.

Case History #1

Dave Case is in his mid-30's and is homesteading 230 acres in northern Minnesota. He lives alone in a log cabin he built by himself, on the top of a granite boulder overlooking a pine-edged lake. His is the only cabin on the lake and he is three miles from the nearest road.

Dave built his one-room log cabin with its huge stone fireplace himself. All the building materials except the glass and some hardware came from his land. He used wooden pegs in construction rather than nails. He put a layer of sod, from six to ten inches thick, on his roof as insulation. He calculates that it makes the temperature 20 percent warmer in the winter and 20 percent cooler in the summer. As an added bonus, wild raspberries have seeded themselves in the sod, and produce a crop of fruit each summer.

Dave's bathroom and laundry is his sauna. He does his laundry by hand while he saunas. The log structure sits above the lake, which he uses both winter and summer to cool off in after his bath--in the winter he cuts a hole in the ice!

He has no running water and uses the lake water or rain barrel water for his household needs.

Dave heats his cabin with wood, but he cooks with propane; he uses about $13 worth a year. Kerosene supplies his light which costs him about $5 a year. Part of the reason he uses so little of each is that he moves out of his cabin every summer into a tent where he cooks outdoors over an open fire. "A person has to have a change, has to get away. I spend a lot of time in that cabin in the winter," Dave says.

Dave intends never to build a road. In the winter he brings in supplies with his dog sled and moves about with snowshoes and cross-country skis; in the summer he uses a canoe to bring in supplies.

He grows 70 percent of his food, a diet which consists of wild fruits, fish and garden vegetables.

His vegetables and fruits are preserved in a variety of ways. He has built a root cellar into a hillside, where the year-round temperature remains around 7° C (44°F). He cuts ice blocks from the lake in the winter, places them in a hole in the ground and has a "refrigerator" until late June.

Dave needs no trash collector because he produces no waste. He buys nothing in cans or jars and any leftovers become garden compost or sled dog food. He intends never to have a telephone or electricity. "One thing I am afraid of is adding convenience to my life," he says.

Case histories #1 and #2 come from Energy Activities for Junior High by the Minnesota Energy Agency and the Minnesota Department of Education, 1977.

Case History #2

Ira and Barbara Bieler and their nine children farm in central Wisconsin. They are Amish, as are 75 percent of their neighbors. The valley they live in has no utility poles. The Bielers, like other Amish, have no telephone or electricity.

Barbara Bieler's kitchen is the center of the family's indoor activity. Here she cooks meals for a family that has done strenuous physical work all day. She cans, pickles, preserves, and dries food. In this room, over the dining table, hangs the only lamp in the house--a pressure lamp much like an ornate version of our familiar gas camping lantern. Hand lamps or candles are available for taking to other rooms when necessary, but most family activity is done in the kitchen, and bedtime is early. This room also contains the black, cast-iron, woodburning stove that heats the whole lower floor. Bedrooms have grates in their floors to allow heat to rise from the stove below. In the corner of the room is a treadle sewing machine at which Barbara and her older daughters make all the family clothes. In years past, cotton and woolen fabric was made by hand and stitched into pants, shirts and dresses by hand.

The Amish were recycling long before the word was coined. Ira says, "Nothing is wasted here." Harnesses are patched for generations; left-over food becomes garden compost or animal food; what few cans the family uses become containers for plants.

Barbara uses a hole in the backyard as a "refrigerator." It is covered with a heavy, wooden door and it keeps butter, milk, cheese (all produced on the farm) at a uniform temperature year round. Another dirt mound with a wooden door at its entrance is a root cellar where Barbara and her daughters store root vegetables, apples, and squash, all grown in a hugh garden. She cans meat, poultry, fruits and vegetables--enough to meet the entire year's needs. There is no plumbing indoors, but there is a hand pump at the kitchen sink. Another pump sits in the yard.

Ira does all his farm work with teams of horses. He raises dairy cows, a few beef cattle, hogs and chickens. The chickens are penned separately--the eaters and the layers.

Ira's traveling is done in a boxy, closed, black buggy, hitched behind a single horse. The Bielers do not go far, and they do not go fast.

Case History #3

Karen and Bob Lightly both work and go to college as well. They rent half of a small house, having three second-floor rooms and a porch to themselves. The house is moderately insulated and has old-fashioned wooden storm windows that must be taken up and down with the seasons. Their gas bills for heat, hot water, and cooking total only $200 for the whole year (1978).

The Lightly's refrigerator is small, only six cubic feet, and has a tiny ice cube compartment but no space for frozen foods. Karen and Bob prefer to eat natural grains and nuts, fruits, cheeses, salads, and fish and seldom do much cooking.

During their limited free time, this couple enjoys music played on their stereo system. They do not own a televison set. Bob is conservative in the use of lights. He and Karen usually study together at the kitchen table to avoid lighting separate rooms.

Karen has an automatic washer but she seldom uses it. She hangs clothes to dry outside in mild weather, but keeps them indoors (for extra humidity) in winter. She likes "natural" looks in fashion and avoids buying any garments that may require ironing. She also consciously avoids using more utilities than necessary because she believes that she should disturb the environment as little as possible. Over a year's time, Bob and Karen's electrical usage averages only 2 kwh per day or 1 kwh per person. (The U.S. average for home consumption is nearly 50 kwh per day.)

For transportation, the Lightly's usually walk or ride buses, depending on the length of the journey. They also bicycle in mild weather, and credit their regular outdoor exercise for their excellent health.

Case History #4

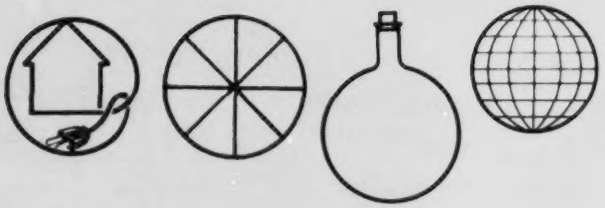
Audrey and Joe Stolid live in a major midwestern city where they both work and send their two children to school. Their modern home is very well-insulated and "all-electric," including heat, hot water, air conditioning, dehumidifiers, self-cleaning oven, ceramic range-top, automatic-defrost refrigerators, dishwasher, and an automatic washer and dryer.

Audrey saves shopping time by keeping her 24 cubic foot deep freezer well-stocked with frozen foods. Her children know that they can get a popsicle or ice cream bar out of it anytime.

Audrey and Joe have a color TV console in their bedroom and a portable set in the kitchen. The family room boasts a large radio-TV console for the children's convenience as well as a second refrigerator to keep soft drinks ready and a microwave oven available for snacks.

Everyone bathes and showers for refreshment both morning and evening. The Stolids enjoy ample supplies of electrically heated water from quick-recovery tanks that also supply warmth to the in-ground swimming pool. The house is always well-lit, whether or not any Stolids are home, because Joe likes to show that he doesn't have to pinch pennies. He is not surprised that his average daily use of electricity is 150 kwh. "I keep as cool as I want and as warm as I want whenever the weather changes. I eat what I want when I want it, and I swim daily six months a year. I like to live comfortably and I can afford it."

Comfort was also the reason that Joe bought a motorhome for his annual fishing vacation. The other fifty weeks of the year, he drives a full-sized car to work and his wife uses a station wagon. This is one family that refuses to be cramped, no matter what.



Life Without Electricity: A Peace Corps Experience

Introduction:

After graduation from the University of Iowa, Jensy Patterson joined the Peace Corps in the summer of 1978. She was sent to Kenya, East Africa where she became one of four teachers staffing a 90-student Harambee high school. The rural village that is her home now lies in mountainous terrain near Lake Victoria and Kisii in western Kenya. The area has only two seasons, the rainy and the dry. Daytime temperatures do not change much throughout the year, but nights during the dry season can be chilly. Here are some of Jensy's comments on her new life without electricity, excerpts from a letter she wrote to a snowbound friend in Iowa:

The Letter:

Keroka, Kenya, January 22, 1979

For your own knowledge, I'll try to describe some of the energy uses here. Of course, there is no electricity. There is some in Kisii town which is about 12 miles away.

Everyone lives in small mud and thatched huts. The only permanent buildings around are the school and my house. Even the small dukas (shops) down the road are made of tin.

Firewood is commonly used if the dead wood can be found. (I came back one weekend to find many of my trees chopped down.) It's hard for these people on the top of the mountain and on the sides because the trees help prevent erosion, yet they need the wood for cooking and occasionally for warmth. They cook in their huts on the floor or in chiko--a small round metal container. It sits on the ground and is similar to our barbecue stoves. The old men in the market make them and sell them for about 15/= to 25/= ($2-$3).

December is also charcoal making month. All over the hills you can see smoke billowing. They chop the wood and cover it with dirt, leaving some small holes, and then light it to remove the impurities. After about 18 hours they have charcoal. This is sold for about 20/= ($ ____) for a large burlap bag. This is what is most commonly used in the chiko cookers. They use kerosene to light them. This is also used in their lanterns.

Candles are also used for light, but not often. (I do use them, but they are expensive here.) Kerosene costs about 11/= ($1.50) for five liters. I also use a pressure lamp which is about 600 candle power, but these are very expensive. Mine cost about 300/= ($43). I almost feel bad about having it, but figure the cost of my eyesight is worth a lot more than the impression these people will get of me having so many things.

A few, very few, wealthy people use a gas cooker. There are also pump stoves run on paraffin and some people use these, but I prefer the charcoal.

After awhile, all this becomes a way of life. I really enjoy not having electricity. Life is very simple without it. People usually go to bed early here too. 9:00 p.m. is "getting very late, madam!"

Kenyans depend on the sun for so much--time, drying clothes, crops. It seems the days are getting longer here too.

Of course there is no running water either. I'm the only one within several miles who has a rain tank. The school provided it, but it leaks and thus I too am dependent on the "river" (small stream actually) for my daily water needs. Because of my cooker I can warm my bath water but most either bathe in the river or out of a bucket; both are chilling experiences, believe me!

Because there are no street lights there is very little transport on the road after 6:30 - 7:00 p.m. The African's eyesight must not adapt too well to driving at night.

Torches (flashlights) are a part of every household. Batteries are very expensive. I have gone through so many. In physics I taught my kids that if you put the cells in the sun when they are weak, this exposure will repolarize them so that they can be used again. They were thrilled.

In all of Kenya there is only one "laundromat." It's in Nairobi and you can bet four of the six machines are always broken. Everyone does laundry by hand, then lays it on the grass to dry. I've learned to fold mine so they don't have too many wrinkles. There are charcoal irons though.

Of course, with no electricity there is no refrigeration. Many simply don't need it. My eggs last about three weeks and up on my hill my fresh butter will stay hard for two weeks. I'm extremely atypical though. No one else has the coolness I have.

There is milk in cartons I buy called UHT--it's ultra heated. Also margarine comes in a can and dried milk is popular. Many people enjoy the "sleeping milk" which is sour and curdled and kept in gourds. Kenyans think that the soured milk is very sweet and they simply can't understand why I don't like it. They use fresh milk only in tea.

Hope this gives you some picture of life without electricity. Cold sodas are unheard of as is beer. You get used to things!

As always,

Jensy

Teacher's Guide to Life Without Electricity: A Peace Corps Experience

There are many areas for discussion or for written question-and-answer responses suggested by this letter. Choose some that reflect your own interests and the subject matter of your course. Or ask a teacher from another discipline to participate in a wider ranging class discussion on ways and means of getting along on a low-energy budget.

Examples of questions you may use are:

1. What renewable sources of energy are mentioned in the letter?

   (Firewood and wood charcoal; sun; also students possibly may mention candles and gas which may be "renewable," depending on the raw material base for each. Candles can be made of beeswax or tallow, which are "renewable" or from paraffin, a non-renewable petroleum by-product. Natural gas, L.P. gas, or propane is associated with oil production from underground reservoirs and is not renewable. Methane or "biogas" from anaerobic digestion of organic wastes is renewable. In fact, the candles and gas to which Jensy refers are petroleum by-products and are therefore non-renewable.)

2. What non-renewable energy sources are mentioned in the letter?

   (Cooking gas, batteries, kerosene, paraffin, candles)

3. Which of the above energy sources did your grandparents use 40-50 years ago?

4. Which of the energy sources mentioned above do you use regularly now?

5. What do you think Jensy likes best about her low-energy-use situation?

6. What does she like least?

7. How has lack of electricity changed her living habits?

   (Note references to cooking and food storage; laundering; sleeping schedule; transportation.)

8. If you were to take Jensy's place in Kenya, what would present the greatest challenge to your present lifestyle?

9. What would be necessary for your survival in a remote Kenyan village? Would you have to take some articles from home with you?

10. Locate Kisii, Kenya on a map of Africa.

    What is its latitude? (0.5° S)
    What is its longitude? (nearly 35° E)
    What is its elevation? (high plateau, mountainous terrain, more than a mile high)

11. What does the above information tell you about insolation (incoming solar radiation) in that part of Africa?

    (Near the equator, solar insolation is maximum. The sun is directly overhead twice yearly and the lowest "winter" angle is comparable to the angle of the summer sun in Iowa. The high elevation means that the atmospheric blanket of air is thin. By day, less insolation is lost to atmospheric screening, but more heat is lost at night than would be true in the lowlands. Cool nights and snow on the highest peaks are possible.)

12. How does the local climate near Kisii moderate basic energy needs (compared to Iowa)?

    (Little additional heat is needed for keeping people warm. Well-sealed homes that need artificial heating and cooling are not necessary for survival. However, heat for purifying water and milk is even more important for good health than here because tropical microorganisms are very numerous. Long growing seasons make long-term food storage less important than in Iowa, but heat is necessary for some forms of preservation--including tea production. Less clothing is needed for personal warmth. Transportation vehicles, where available, run more efficiently in warm climates than in cold ones. Animals require less food to maintain body temperature and growth rate than they do in more variable climates. Trees grow faster so, if replanted, replace firewood faster. Daylight hours are never much longer nor much shorter than 12 hours so opportunities for evening activities are very limited unless some other source of light is available, even at the peak of summer.)

13. How much does a large bagful of charcoal cost in western Kenya?

    (On the first page of Jensy's letter it says charcoal costs 20/= ($___)
    Clues to the dollar equivalence are

    --that cookers cost 15/= to 25/= which is $2-$3.

    If 15/= is $2, than 1/= is $\frac{2.00}{15}$ or 13 cents

    If 25/= is $3, then 1/= is $\frac{25}{3.00}$ or 12 cents

--that kerosene costs 11/= or $1.50,

so 1/= is $\frac{1.50}{11}$ or 13 1/2 cents

--that her lamp cost 300/= or $43,

so 1/= is $\frac{43}{300}$ or 14 cents.

Using these figures, charcoal at 20/= cost $2.40 to $2.80 in U.S. dollars.

14. How is charcoal made in the U.S.?

15. What are the uses of charcoal in the U.S.?

16. Why is fresh milk heat-treated?

(Like "pasteurization," the term more common in U.S., ultra heat treatment destroys several kinds of disease-causing organisms without much change in the chemical composition of the milk. It also slows the natural fermentation of milk, so it tastes fresh longer.)

17. What are the energy-related advantages of dried milk?

(Extra heat is required to process dried milk. However, this "expense' is more than offset by great energy savings in refrigeration, packaging materials, and transportation costs in distributing milk. Removing the water reduces the weight of milk by 90% and the volume by 75%. No refrigeration is required until or unless the milk is remixed with water for drinking. If kept dry, the milk powder lasts for months.)

18. If wood and charcoal were the only fuels available, how might food preparation methods and daily menus be affected?

Oil Embargo Auction

Objective:

To give students an idea of how much power is involved when someone has something that everyone wants, and to start a discussion.

Directions:

Divide a large group into groups of three or four. Each group will represent a country. One group will represent Saudi Arabia and will get to own two dozen large chocolate chip cookies, a desired edible commodity. Ideally, the number of cookies used will be less than the number of students in the class.

One country will be given 1,000 play dollars (Monopoly money can be used). This group will represent the U.S. The other groups are small countries. They will have only 100, 50, and 25 dollars to work with.

Have the Saudi Arabian group decide how much they will sell the cookies for--hiking the price after selling a few will be fine. Saudi Arabia may pay another country to transport the cookies.

After the cookies are gone, ask the group to return to the discussion circle.

Discussion:

1. Did you ever feel frustrated that the cookies soon would be all gone and you could not buy them?
2. What could have been done to have divided the cookies more evenly?
3. Can the world's oil be shared in a similar way?
4. Did you find your money gone when you bought the cookies? Who has all the money? What does this mean to you?

Teacher's Guide to Oil Embargo Auction

The fact that U.S. citizens use much more petroleum per person than any other people in the world should be emphasized, along with the fact that half of the U.S. oil consumption depends on imports. Should our addiction to "chocolate chip cookies" be fed so long as dollars are available to pay for them, if satisfying such an appetite deprives other people of any chance to get some? It is strongly recommended that some background information on Saudi Arabia, its people and its resources, be provided along with this simulation.

Resentment of Arab decisions to limit the quantity of oil exports and to raise prices arbitrarily is reflected in many 1979 newspaper cartoons and newscaster commentaries. Appreciation of the limited, non-renewable quality of the resource on one hand and the great needs and aspirations of the people in oil-producing countries is seldom expressed.

When Forbes (June 1, 1977) magazine interviewed Gazi Gosaibi, 37-year-old Saudi Minister of Industry and Electricity, he pleaded, "Unless you bear in mind this yearning of our people to have a human living after about 3,000 years of subhuman existence, I don't think you will find it possible to understand what goes on in Saudi Arabia." Personal experiences of this young Arabian were that his mother died of typhoid at 28 because there was no doctor in town; scorpions in the house stung him frequently; infant mortality rate was 60-70%; there was no electricity and candles were a luxury, as they still are in many other countries. (See LIFE WITHOUT ELECTRICITY activity) Now he is in a hurry to provide his fellow citizens with hospitals, roads, electrical power, and communications systems. But he also anticipates a future in which oil supplies will be exhausted and a more diversified base for international trade must be available for survival in the modern world. In other words, he must convert some of his cookies into means of producing basic goods for the future.

You may want to consider using something more tangible than play money for students to use in exchange for cookies. Bean seeds or corn kernels have energy potential that can grow if they are planted correctly. Ice cubes, volumes of water, or assorted nuts and bolts could represent critical resources or technology respectively.

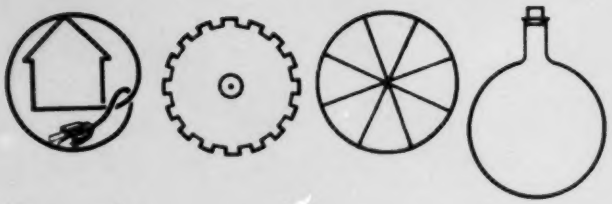
The Baker's Dozen

1. List all electrical devices in your house.
2. Total this list.
3. Check around the class to see who has the longest list. Read it aloud so others have a chance to add any appliances they may have forgotten.
4. Check the 13 electrical devices that are most important to you.
5. Draw a line through the four you can most easily do without.
6. Draw a circle around the four you could <u>least</u> easily do without.

Limit yourself to a one or two paragraph answer for the following questions.

7. What causes black outs and brown outs?
8. Who actually controls a public power company?
9. What are the particular advantages of electricity?
10. What do you do to conserve electric power?
11. Generate a list of essential services which require electricity that you and your community are dependent upon.
12. Explain how power companies contribute to air and thermal pollution.
13. Describe how your favorite electrical device may be powered in the year 2010.

Student activity suggested by Paul D. Knapp, Linn-Mar High School, Marion, IA.



Cabin Fever I

Surface Area

Introduction:

Heat naturally travels from a warmer place to a cooler one, or from an energy "source" to an energy "sink." How quickly that transfer happens depends on many factors. In the case of buildings that need heating or cooling, some of the considerations are:

How much surface area is conducting heat? (CABIN FEVER I)
How well insulated is it? (CABIN FEVER II)
How tightly sealed is it? (CABIN FEVER III)
What does the site and its plantings contribute to the energy flows? (CABIN FEVER IV)
What are the activities of its occupants? (CABIN FEVER V)

Surface area or "skin" of a building varies with its design. The more exposed "skin," the greater is the potential for heat transfers. However, the smallest house is not necessarily the most efficient. For many designs, small increases in linear dimensions yield larger increases in volume. Even for homes or apartments of the same floor area or living space, their general shape and arrangement makes some more efficient than others. In general, the larger the volume of inside air to the outer surface areas of floor, walls, and roof, the slower the rate of total heat exchange between the inside and the outside.

Background:

In order to consider the amount of surface area conducting heat, we need to calculate floor area, volume, surface area, and the ratio of volume to surface area. Let's consider each of these factors in turn.

a. Floor area is length times width on the rectangular plans, with 8 ft. being the height of each unit. The "L" plan is best calculated in sections. The "A" frame has a standard rectangular base, 30 ft. x 35 ft. The dome has a circular floor for which the area is πr^2 or 3.14 x 18 ft. x 18 ft.

b. Volume involves all three dimensions, length x width x height. Again, the "L" is best considered as the sum of each rectangular section. The A-frame is 1/2 of the cracker box (rectangular solid), or area of the triangle times length. The dome is 1/2 of a sphere so its volume would be 1/2 ($4/3 \pi r^3$).

c. Surface area includes all wall, floor, and ceiling areas.

For the "ranch," for example, you have both a floor and a ceiling 24 ft. x 43 ft.; there are two walls 24 ft. x 8 ft. and two walls 43 ft x 8 ft. So total surface area is:

$$\begin{aligned} 2 \times 24 \times 43 &= \_\_\_\_\_ \\ +\ 2 \times 24 \times 8 &= \_\_\_\_\_ \\ +\ 2 \times 43 \times 8 &= \_\_\_\_\_ \end{aligned}$$

Total: _____ sq. ft.

Some formulae to recall: Area of a triangle is 1/2 altitude times the base. Area of a circle is πr^2. Surface area of a hemisphere is $1/2\ \pi d^2$.

d. A ratio is a comparison between two figures. In comparing the volume of air enclosed to the outer surface area where exchanges of heat take place, we are assuming that air escapes the way people leave a supermarket, taking the shortest "line" out. If the number of check-out counters varies from market to market, the same volume of customers will be served faster in some stores than others. Similarly, if the surface area figure is close to that for volume, the ratio will be a small number (fast exchange, "short line" at the check-out). If the surface area is limited compared to the volume, the ratio will be a larger number (slower exchange, "longer line" at the check-out).

Because interior air has been deliberately heated or cooled at some energy cost, slowing down its exchange is desirable. Designs that provide a minimum exterior surface in relation to interior air space (higher ratio) are likely to require less energy for space heating and air conditioning than designs having a low ratio. This assumes that the buildings being compared are alike in materials, construction, insulation, window area, occupants and other energy-use related factors.

Directions:

With this in mind, compare the heat retaining advantages of various shapes for some modest homes. Using the dimensions given on the following chart, do the calculations necessary to complete it.

After you have completed the chart, answer the following questions.

1. How similar are these houses/apartments in functional living area?

   a. What is the average floor area of each living unit. Assume for the sake of your calculations that the 2-Story Square is a duplex (first calculate its average floor area). Make the same type of calculation for the 4-Unit Apartments.

b. Which house plan shows the largest difference (plus or minus) from the average floor area?

c. Using your calculations in 1b, determine the largest percent of difference from the average floor area.

$$\frac{\text{Largest Difference in Floor Area}}{\text{Average Floor Area}} \times 100 =$$

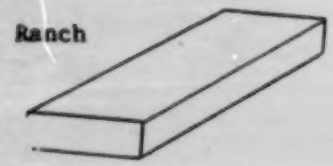
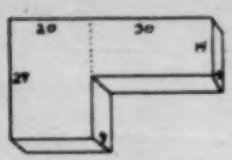
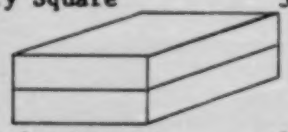
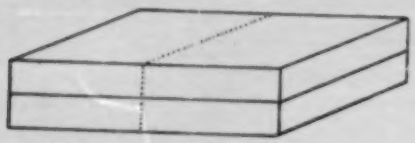
2. Which design has the best potential for slowing down heat losses?

3. Which design would be easiest to insulate? Describe how you would do it.

4. Can you suggest another design that would be better in slowing heat transfers?

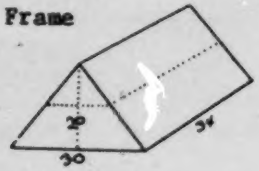
Name _____

Student Worksheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
Square	32 x 32 x 8				
Ranch 	24 x 43 x 8				
Small "L" 	20 x 28 x 8 and 30 x 14 x 8				
2-Story Square 	32 x 32 x 16				
4-Unit Apartments 	64 x 32 x 16				

Student Worksheet

Name _____

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
"A" Frame 	30 x 34 x 20 ft. peak				
Dome	36 ft. = diameter, 18 ft. = radius				

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1. a. _____
   b. _____
   c. _____
2. _____
3. _____
   _____
   _____
4. _____
   _____
   _____

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
Square	32 x 32 x 8	1,024	8,192	3,072	2.67
Ranch	24 x 43 x 8	1,032	8,256	3,136	2.63
Small "L"	20 x 28 x 8 and 30 x 14 x 8	980	7,840	3,208	2.44
2-Story Square	32 x 32 x 16	2,048	16,384	4,096	4.0
4-Unit Apartments	64 x 32 x 16	4,096	32,768	7,168*	4.57

Teacher's Answer Sheet

House Shape	Exterior Dimensions (ft.)	a. Floor Area ($ft.^2$)	b. Volume ($ft.^3$) (to heat & cool)	c. Surface Area ($ft.^2$)	d. Ratio Volume/ Surface Area
"A" Frame	30 x 34 x 20 ft. peak	1,020 + loft	10,200	3,320	3.07
Dome	36 ft. = diameter 18 ft. = radius	1,017.4 + loft possible	12,208.3	2,034.7	6.00

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1. a. Average floor area/living unit + 1,017.3 $ft.^2$

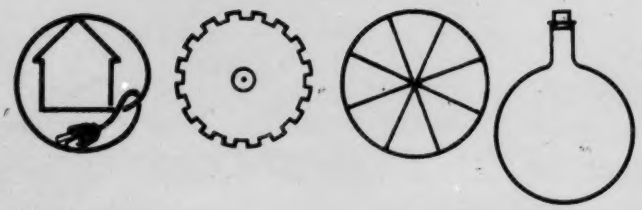
   b. Small "L" house shape

   c. 3.6%

2. In terms of potential, the dome is best due to less escape routes for heat transfer.

3. There is <u>no one right answer</u>. Ease of insulation depends upon local limitations on construction, materials, installation expertise, costs, and time.

4. A number of valid suggestions may be proposed including berming, double wall or envelope construction, underground homes, row housing with shared walls, windowless north walls, etc.



Cabin Fever II

Insulation

The second factor affecting how fast heat transfers in or out of a building is the materials of which that building is constructed in the first place. The exterior surface or "weatherskin" transfers heat into or out of the house at a rate that varies with the kinds and thickness of materials incorporated into the walls.

Every building material has its individual insulation value. It can be expressed as U, coefficient of heat transfer (BTU/hr/ft^2/°F), or the resistance to heat flow (R). These values are reciprocal: $U = \frac{1}{R}$. The higher the "R-value," the better the resistance to heat loss. R-values are additive--thicker material or a combination of materials usually means increased insulating value.

Typical Heat Resistance (R-Value) of
One Inch of Various Materials

Material	R/inch
polyurethane foam	6.25
shredded newspaper	5.50
polystyrene board	5.26
cellulose (loose)	3.70
fiberglass (batt)	3.17
perlite	2.70
rock wool	2.20
softwood (fir, pine)	1.25
air space	0.91
dry snow	0.80
light, dry soil	0.40
plaster	0.18
heavy soil, damp	0.09
concrete	0.08
average rock	0.06

Source: ASHRAE Handbook of Fundamentals and J. Scalise, Earth-Integrated Architecture.

Amount of air spaces or pockets separating the solid parts in the material is a second important determinant of its ability to slow heat conduction. The more air spaces and the lower the conductivity of the solid between them, the better the insulation value. So it should not be surprising to find that popcorn and shredded newspapers are good insulators. (A large air space is not a good insulator because convection currents develop which assist heat flow.)

Reflective metal coatings can also act as effective barriers against heat loss. Aluminum, chrome, silver, or other shiny surfaces reflect long-wave (heat) radiation. Adhesive metallic films for windows are comming into use, making "heat mirrors" of these openings without blocking an insider's view. If this foil has an air space in front of it, it can reflect up to 95% of the heat energy before the heat is absorbed by the insulation or glass and conducted outward. Architect David Wright reports that a 1/4 inch airspace, when lined with foil, attains an R-value of 2.5.

R-value alone is not the criteria for selecting building materials or added insulation. Fire-resistance, structural qualities, pest control, space availability, cost-effectiveness, ease of installation, and energy required for production and delivery are some of the other factors to be considered in determining the best choice for a particular building and location.

Since heat rises, the ceiling is the most important part of buildings to insulate well. It keeps more heat in the room and slows its escape upward. This stabilization then reduces the air exchange rate and the pulling in of colder outdoor air. The furnace will run less, the interior will be more comfortable, and energy savings can be expected.

Well-insulated walls and floors are also very important, however. In order to get "thermal balance" or even heat throughout a home, new dwellings designed for energy efficiency use more insulation in exterior walls. 2" x 6" studs permit thicker walls and more insullation in conventional construction. "Arkansas Plan" houses built with 6" wall and 12" ceiling insulation (R-19 and R-38) have been using one-third the heating and cooling dollars of standard new homes.

Suggestions for Student Activities:

1. The Iowa Extension Service in Ames and many local utility companies provide an "energy audit" service. Call or write for audit forms on which students list basic features of their homes, apartments, or school: number of windows, length of exterior walls, floor areas, style and number of exterior doors, etc. Counting and measuring can be done by junior high students; only basic math skills are required. Send the forms back to the sponsor for a computer-assisted analysis of likely places that changes in the building or in the activities of its occupants may save energy, or consider doing the economic analysis with the help of a detailed, step-by-step instructional booklet, "In the Bank or Up the Chimney." Published by HUD, this resource is available for $1.70 from the Sup't. of Documents, Government Printing Office, Washington, DC 20402. Ask for # 023-000-00297-3.

2. Use several identical packing boxes as "model houses." Put a thermometer inside each in such a way that it can easily be read without disturbing the box. Make a small window, of the same size and material for each box. Put a second thermometer on the outside of each box. Line the walls and "ceiling" of each box with a different kind of insulation. Put each box over a liter beaker full of boiling water or full of ice cubes and record temperature differences (inside vs. outside and box 1 vs. box 2, etc.) over time.

   You may want to use the "thermos bottle" analogy in introducing this activity. A good thermos has a high surface-to-volume ratio, excellent insulation, a radiant barrier, and only one or two well-sealed openings. It works equally well to keep cool things cool and warm things warm. Slowing heat flow works both ways in a well-designed and insulated building.

3. Build an igloo on the school grounds in winter. Tamp snow firmly into shoe boxes or similar containers. If it is not "packing snow," add some water and let the blocks freeze solid. Pile up "blocks" on a circular base, leaving an opening on the south side. Make each successive layer overhang the previous one slightly on the inside. Use extra snow "mortar" if desired to smooth interior walls. When completed, temperature measurements of inside (warmed by student workers) can be compared to those outside. Ask students to explain differences and to suggest improvements that would make the structure a better heat-conserver. Research on housing styles (past and present) within the Arctic Circle would be appropriate.

4. Contact a local banker, savings-and-loan officer, or home builder familiar with F.H.A. requirements. Ask what current construction practices have been recently adopted with energy conservation in mind. Collect pictures and floor plans of contemporary homes or other buildings where people work, shop, or recreate. Label features that meet or exceed basic requirements for energy efficiency.

5. With cooperation of the school custodian, maintenance supervisor, or other knowledgeable person, survey the school facilities with energy efficiency in mind. Is the school insulated? how? Could insulation, storm windows, shutters, drapes, lowered ceilings, or other energy-saving features be added? Or could activities of the people in the building be changed to save energy? Keep in mind that each person in the school gives off about as much heat as a 100 watt incandescent bulb burning continuously. Can that "people-power" be used?

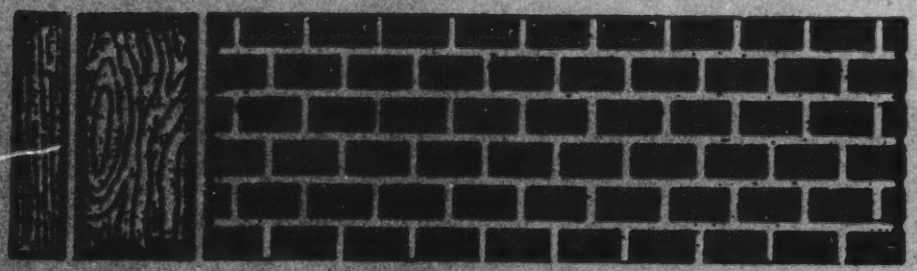
6. Cars, trailers, and motor homes are also "weatherskins" that shelter people from the climate. Cars, at least, are likely to be available on the schoolgrounds and could be subjects for heat-flow measurements. In the Sun, in the shade; windows open, windows closed; different colors, varying amounts of glass area, trunk vs. hood vs. passenger compartment temperature changes over time are all possible forms of data to collect on the efficiency of vehicles to resist heat flow.

Be prepared to discuss conflicting requirements for cars. They should be strong enough to resist demolition; light enough to be economical in use of fuel; comfortable enough to make traveling pleasant; good-looking enough to make people want to buy them. Are there materials that can satisfy those criteria and also minimize heating and cooling requirements for passengers? What would they cost? Would changing people's habits, needs, or expectations be easier than making energy-efficient cars?

Have some students check the additional cost of factory-installed air conditioning on several models of cars, as well as weights of the units. Remind them that these additional 300-500 pounds will reduce fuel economy every time the car is driven--winter or summer--because the greater the weight moved, the greater the amount of fuel needed to move it. Further, when an auto air conditioner is in operation, its use reduces fuel economy by 1-2 mpg, most automotive guides report. How many days a year is this option necessary? How much does it cost to have it available for those days? What other alternatives do motorists have?

Free Resource Suggestion:

Home Energy Savers' Manual, James W. Morrison, ed., 1979, available from Iowa Energy Policy Council, 707 E. Locust, Des Moines, IA 50319. Single copies are available free to teachers. Classroom copies may be available at cost; write for a quotation.

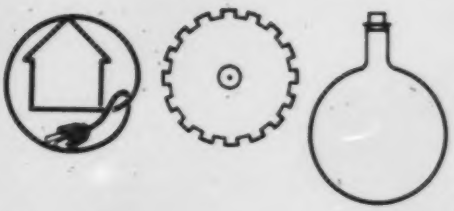


Forget inches: It's R-values that count.
6 inches of fiberglas have the same R-value as 15 inches of wood or 7 feet of brick

The insulating value of any material depends on both the R-value and the amount (thickness) used. The two variables must be juggled simultaneously.

Some insulation guidelines mention inches only, as if quantity and quality are the same. Others specify R-value per inch only. But these are both important and inter-related variables. Total R-value is the sum of R-rating/inch times thickness of the material(s) used over a particular area.

In unfinished floor attics with only 2"-3" space available for insulation, the highest R-value may determine choice, giving maximum resistance possible in a fixed area. But where space is not a limiting factor, cost or availability or ease of installation may make a lower R-inch material, used in quantity, the best choice. Where underground buildings are possible, low R-value masonry and earth berms several feet thick may be the most practical choice for an energy efficient building.



Cabin Fever III

Infiltration

In many homes the greatest single factor in heating and cooling losses is infiltration. Infiltration is the outside air coming in through open doors and windows; through cracks around windows, doors, skylights, and vents; and through any other break in the "weatherskin" of a building, such as fireplaces, water faucets, exhaust fans, electrical outlets, and joints where different materials meet.

In a poorly sealed house, inside air may leak out and be entirely replaced every fifteen minutes.

Temperature differences alone start these air-exchanges. Warm air naturally flows to cooler regions. But wind can make the rate of infiltration much higher. Wind creates a pressure differential that forces air into a building on the windward side while it sucks air out of the leeward side.

Wind speed also makes the effective or humanly experienced temperature less than the actual thermometer reading. Wind chill factor is the relationship between cooling conditions at various temperatures and wind speeds, as measured by the freezing rate of water sealed in a plastic container. Such a set-up is equivalent to human flesh. It was devised by Antarctic experimenters to learn how fast their faces would freeze under its severe weather conditions. The super-cooling effect of wind has relevance to heating requirements also, especially in poorly-sealed buildings or in those sited where high winds are prevalent. Occupants will likely feel chilled on windy days even if the furnace keeps the room air at an ordinarily comfortable temperature.

The main methods of stopping infiltration are caulking and weatherstripping.

Caulking is soft material that can be squeezed into all non-moving cracks and joints of a building. Areas that commonly leak air and should be sealed are the space between walls and floors; where the outside wall meets the foundation; around window and door frames, electric outlets, ducts and vents, and any pipes that penetrate foundation walls; around the chimney shaft as it passes through the attic; and around recessed light fixtures.

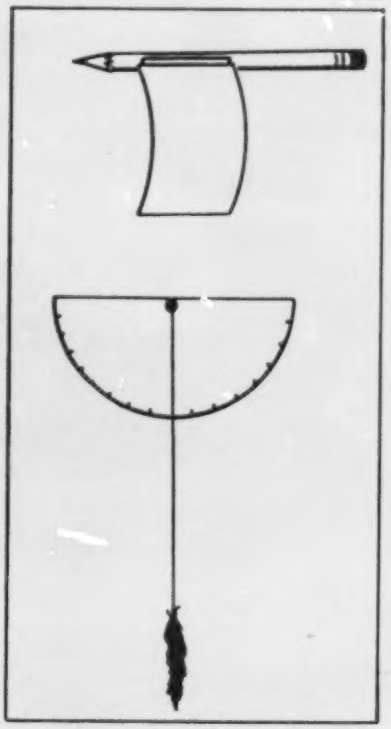
Weatherstripping is used around windows and doors that open and close. Many kinds are available to reduce air flow around their edges. A door on the windy side of the house will likely need more than weatherstripping or a storm door to prevent infiltration, however. An enclosed vestibule is recommended if this entrance must be used.

Suggestions for student activities:

1. Construct a draft detector from a pencil, scotch tape, and plastic food wrap. Cut a 12 x 25 cm strip of plastic wrap and tape one of the 12 cm sides to the pencil. Blow the plastic gently to see how freely it responds to air movement.

   OR

   Construct a draftometer from a protractor, push-pin or thumb-tack, thread, and a feather. Tie one end of 60 cm of thread to the tack or pin. Attach the feather to the other end. Push the pin through the hole in the protractor and hang it on the corkboard or window framing so that the bottom edge of the protractor is upward and level with the floor. Blow on the feather and notice how the thread intersects various places on the circular arc. You can use this device to make comparative measurements.



   Using either the draft detector or the draftometer on a day when forced-air furnaces are not operating, students can test the classroom and other school areas (or their homes and cars) for air leakage by holding or pinning the device near edges of windows and doors, by fireplace openings and by ducts or vents. Encourage record-keeping on length (perimeter) and the location (N, S, E, W) of openings that showed evidence of drafts.

2. Visit a hardware store to find out what is available to close air leaks around various openings. Or invite a local merchant to display and explain the use of caulking and weatherstripping materials to the class. Or bring in examples of weatherstripping and let students practice installing some under supervision on the school building or on a nearby home.

3. Using examples of at least three different types and prices of caulking cartridges and a caulking gun, have students press out beads of caulking onto broiler foil or onto small pieces of wood. Label the various examples for later identification. Arrange to heat-dry the samples (in your solar oven, if available--or at 150°F in a conventional oven); and then freeze, heat-dry and freeze the samples again for several consecutive days. Have students note any observable differences (in color, hardness, shrinkage, cracking, etc.) between the various samples. Encourage cost-effective comparisons. The following chart is suggested for record keeping:

CAULKING: Life-Cycle Costing

Type	Price	Useful Life	Cost per Year
Oil or resin	(low)	1-4 years	
Acrylic, latex, butyl	(moderate)	3-12 years	
Elastomerics: hypolon, polysulfide, silicon	(high)	10-20 years	

Resource Suggestions:

"Consumer's Guide to Caulking" in Mechanix Illustrated, September 1976.

"Sealing the Leaks" in How to Cut Your Energy Costs, U.S. News and World Report Books, $7.95, 1978.

"Save Energy, Save Dollars," a consumers' manual about conservation of energy in the home, available for $1.50 from Mailing Room, 7 Research Park, Cornell University, Ithaca, NY 14853.

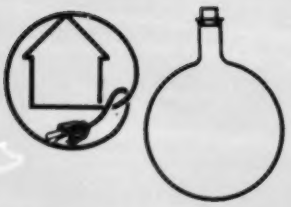
Wind Chill Factor

Wind speed (mph)

Thermometer (°F)	5	10	15	20	25	30	35	40*
35	33	21	16	12	7	5	3	1
30	27	16	11	3	0	- 2	- 4	- 4
25	21	9	1	- 4	- 7	-11	-13	-15
20	16	2	- 6	- 9	-15	-18	-20	-22
15	12	- 2	-11	-17	-22	-26	-27	-29
10	7	- 9	-18	-24	-29	-33	-35	-36
5	1	-15	-25	-32	-37	-41	-43	-45
0	- 6	-22	-33	-40	-45	-49	-52	-54
- 5	-11	-27	-40	-46	-52	-56	-60	-62
-10	-15	-31	-45	-52	-56	-63	-67	-69
-15	-20	-38	-51	-60	-67	-70	-72	-76
-20	-26	-45	-60	-68	-75	-78	-83	-87
-25	-31	-52	-65	-76	-83	-87	-90	-94
-30	-35	-58	-70	-81	-89	-94	-98	-101
-35	-40	-64	-78	-88	-96	-101	-105	-107
-40	-45	-70	-85	-96	-104	-109	-113	-116

Wind chill index numbers represent the temperature (under calm conditions) that would have equivalent cooling power on exposed flesh or water.

*Wind speeds greater than 40 mph have little additional cooling effect.



Cabin Fever IV

Site and Plantings

If people consider Sun, wind, Earth, and trees as natural heaters or air conditioners, they can make use of their effects to improve comfortable living and reduce its cost. The setting of a home on its site and the landscaping around it can affect how sunshine and wind flow over and into the living quarters. Tests done in New Mexico show that surface orientation alone can affect a heating bill as much as 16%.

The terrain on which a house is built can be a factor in its heating requirements. Cold air sinks. Buildings located in valleys or on the north side of hills are often bathed in colder air than are counterparts on higher and sunnier slopes. Protection from winter winds by a hillside, earth berms, trees, neighboring buildings, or a tall fence can cut heat losses from levels that more exposed buildings experience. A large pond built where the wind blows over it before meeting the house can also moderate its effects.

Prevailing winds vary with the season. In Iowa they generally come from the northwest in winter, the southwest in summer. Your local weather bureau can tell you the recent history of wind patterns in your area.

If your house is not already well-protected from the winter winds, consider planting appropriate trees or shrubs to divert the mainstream of the wind from your house.

On the north, northeast, and/or northwest sides of the house, a windbreak of evergreen trees can reduce infiltration, wind chill, and snowdrifts. Ends of the windbreak should extend 50 feet beyond the end of the area to be protected. Ideally, the trees should be dense hemlocks, fir, or spruce and be planted at a distance four to five times the height of the house to be protected. A single row of evergreen trees as tall as the house can reduce air infiltration 40% according to researchers at Princeton University who tested scale models in a wind tunnel. City dwellers may have a neighboring house standing close enough to provide a man-made windbreak. Or a tall fence can provide a satisfactory windbreak wherever trees are not practical.

On the southeast, southwest, and south where trees may be needed both for summer shade and for windbreaks, deciduous trees (those that drop their leaves every fall) are the better choice. They won't block the winter Sun that can help warm the building. (Every home is a passive solar home, gaining some solar heat no matter what its design. But some homes trap that heat much more efficiently than others. Give your existing home every advantage.) Deciduous trees also shade the house during summer months, and release significant amounts of moisture to the night air; both activities have a cooling effect.

Small evergreens planted near a foundation wall so that air space is trapped between the shrubbery and the house provide some additional insulation in addition to wind protection. Plants that grow to form a dense, solid wall of greenery are best.

If your homesite is unsuitable for growing trees, some alternatives for shade are roof overhangs, porches, vented awnings, shades, draperies, and beadwall windows. Insulated shutters can be used for windbreaks too. Most existing homes would use less energy for space heating and cooling if a combination of strategies is used.

If your home or apartment site already has considerable landscaping, look at the plants with a new critical "energy eye". Are they placed to work as natural heat savers and air conditioners or are they there merely for show?

Resources:

"Energy Efficient Construction in New Homes," pamphlet available free from Cooperative Extension Service of Iowa State University, Ames, IA 50011.

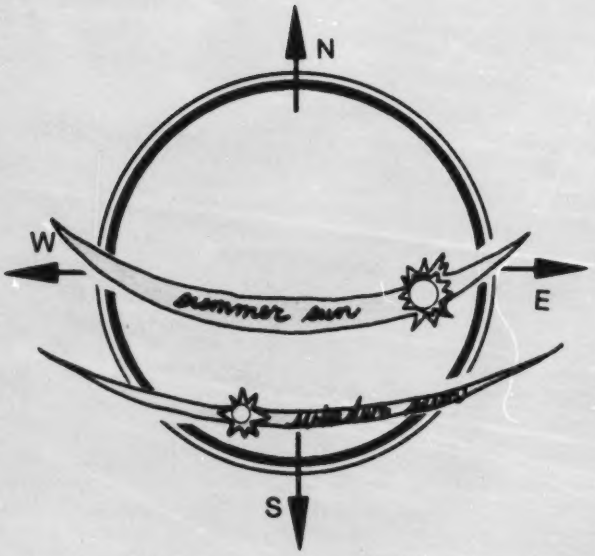
Natural Solar Architecture by David Wright (1978) includes much detailed information on site considerations presented in large-print and chatty style; illustrations on every page.

Solar Dwelling Design Concepts, U.S. Government Printing Office, Stock # 023-000-00334-1 (1976) features a dozen pages of diagrams and text on integration of siting, plantings and buildings.

Underground Design by Malcolm Wells (1977) is mostly drawings and photographs of imaginative building projects that maximize natural environments to conserve energy and to preserve visual appeal of the site. Despite the title, several of the earthy buildings described are above grade level, and some are even several stories high.

Activity Suggestions:

1. Ask students to do the following: Draw a large compass circle similar to this diagram and mark the N-S and E-W axes. Shade in the approximate path of the winter and summer Sun. Draw arrows outside the circle to indicate direction of prevailing summer and winter winds in your area. Then sketch the general shape of your house, school, or apartment building in the middle of the circle, being careful to keep its longest outside wall facing the same direction in your circle as it does on its lot.

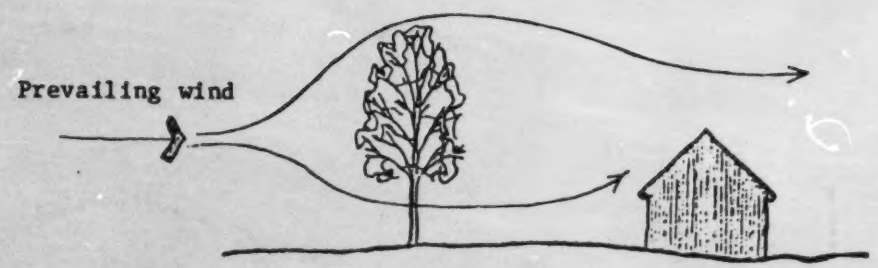


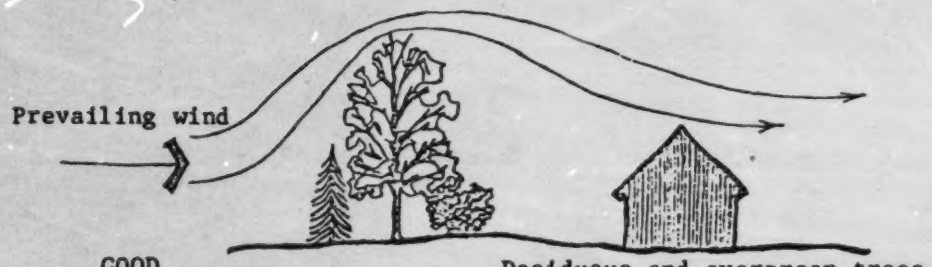
Considering the paths of the Sun and wind relative to your building, where should shaders and/or deflectors be placed? Are there any plantings there now?

2. Invite a local nursery owner to your class to describe and show pictures of trees and shrubs that grow well in your area. Ask him questions about growing rate, longevity, soil requirements, wind resistance, and disease problems of common evergreens and deciduous trees. What is the basis of choice for most customers? How will energy shortages affect his business? What advice does he give for landscaping to conserve energy?

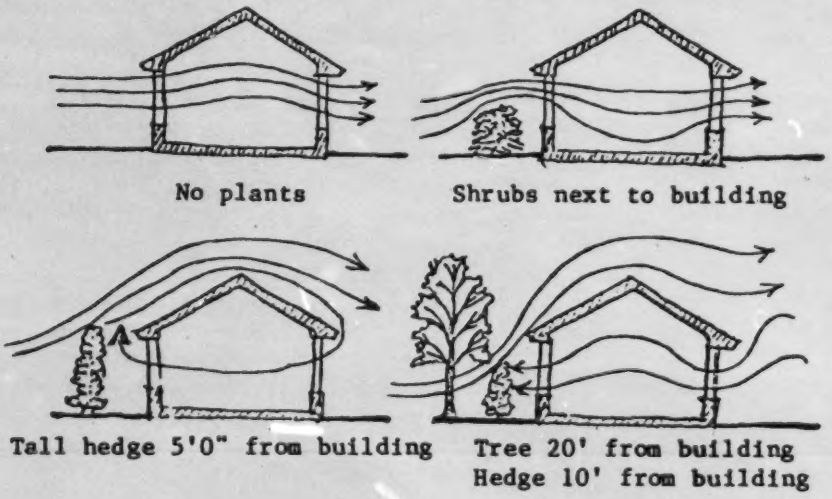
3. Assign students to ask a local builder or real estate developer about popular building sites in your area. Are hilly plots an advantage or a disadvantage and why? What site-related factors are most important to buyers today? Are these choices the same as those made 10 years ago? Is the energy situation likely to change people's site preferences in the near future? Are there any especially well-used sites (relative to energy conservation) in your area that your class may visit?

4. Encourage students to use the school or public library to look for articles in current magazines on earth-bermed, underground, solar-sited, earth-tempered, aerodynamic, and/or passive solar buildings. Readers' Guide to Periodical Literature is a good tool to use. Look for references under "homes," "landscaping," and "architecture." Make a model, poster, report on the most energy-conserving home you read about, or one that you can create by combining features mentioned in the readings.



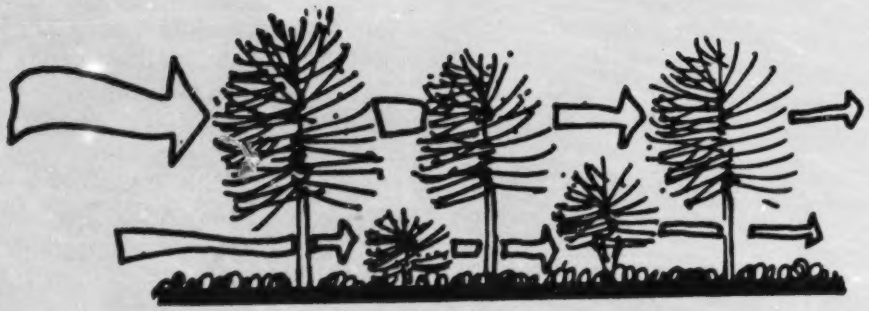


Strategically located evergreens help deflect harsh winds



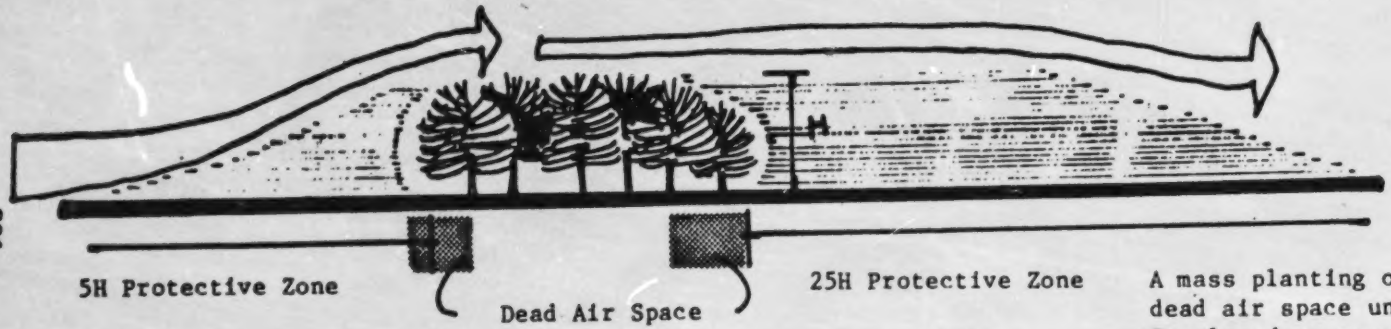
Strategically located plants can direct breezes into buildings in warm seasons and also act as windbreaks in cold seasons.

Reprinted from "State of Vermont Energy Conservation Guidelines," prepared by the Vermont Public Service Board and the Agency of Environmental Conservation (Montpelier, April 1974).

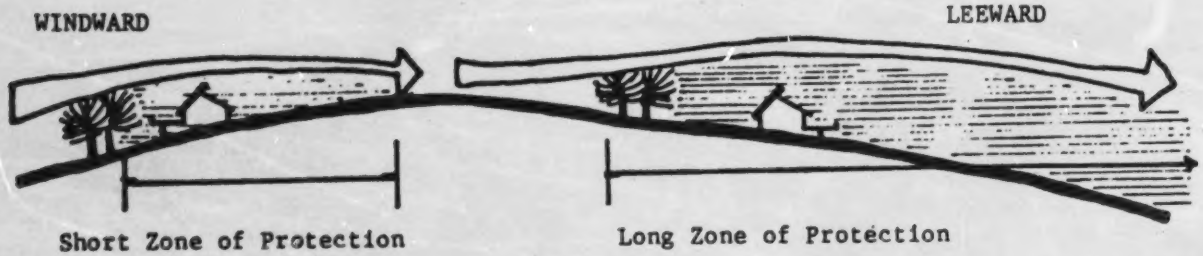


Multiple Braking Effect

Multi-layered vegetation including canopy trees and understory trees or shrubs provides a multiple braking effect, substantially decreasing the wind velocity moving over a site.



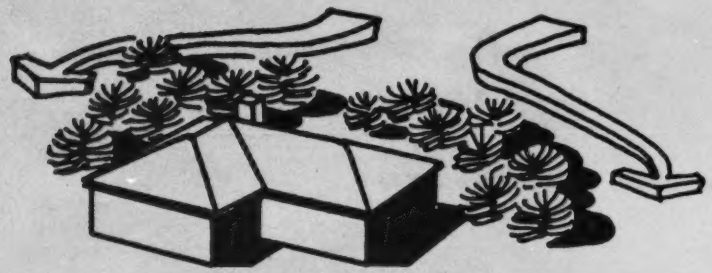
A mass planting of trees provides a dead air space under and around itself. It also decreases the air velocity 5 times its height to windward and 25 times its height to leeward of the planting.



Planting on the leeward side of a hill substantially increases the downwind zone of reduced air velocity, while planting on the windward side correspondingly decreases the zone of protection.

From Solar Dwelling Design Concepts, HUD, 1976.

Fences, walls or vegetation can block natural air flow patterns. Care must be taken during site design to provide the necessary visual control while avoiding adverse climatic conditions, as cooler air flows downhill in the evening. Fences, walls or plantings should not unintentionally dam this flow and thus create a cold air pocket where it is not wanted.



Vegetation properly placed can deflect rather than dam cold air flow.

Vegetation may be preserved or placed in such a way as to channel or block daily or seasonal air flow patterns.

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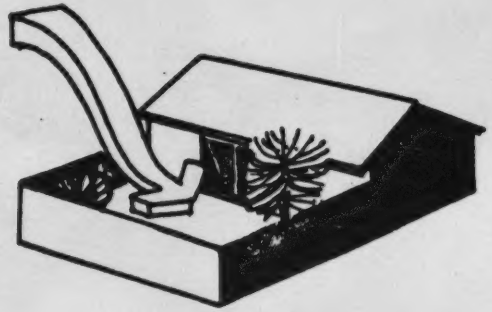
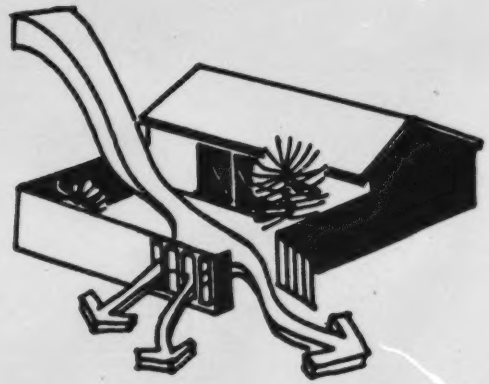
From Solar Dwelling Design Concepts, HUD, 1976.

Dwelling unprotected from cold air flow.



Cold air trapped by fence.



Fence design can provide for cold air drainage.

SITE ORIENTATION CHART

Objectives / Adaptations	Cool	Temperate	Hot Humid	Hot Arid
	Maximize warming effects of solar radiation. Reduce impact of winter wind. Avoid local climatic cold pockets	Maximize warming effects of sun in winter. Maximize shade in summer. Reduce impact of winter wind but allow air circulation in summer	Maximize shade. Maximize wind	Maximize shade late morning and all afternoon. Maximize humidity. Maximize air movement in summer.
Position on slope	Low for wind shelter	Middle-upper for solar radiation exposure	High for wind	Low for cool air flow
Orientation on slope	South to Southeast	South to Southeast	South	East-southeast for P.M. shade
Relation to water	Near large body of water	Close to water, but avoid coastal fog	Near any water	On lee side of water
Preferred winds	Sheltered from North and West	Avoid continental cold winds	Sheltered from north	Exposed to prevailing winds
Clustering	Around sun pockets	Around a common, sunny terrace	Open to wind	Along E-W axis, for shade & wind
Building Orientation*	Southeast	South to Southeast	South, toward prevailing wind	South
Tree forms	Deciduous trees near bldg. Evergreens for windbreaks	Deciduous trees nearby on west. No evergreens near on south	High canopy trees. Use deciduous trees near building	Trees overhanging roof if possible
Road orientation	Crosswise to winter wind	Crosswise to winter wind	Broad channel, E-W axis	Narrow, E-W axis
Materials coloration	Medium to dark	Medium	Light, especially for roof	Light on exposed surfaces, dark to avoid reflection

*Must be evaluated in terms of impact on solar collector, size, efficiency and tilt

From Solar Dwelling Design Concepts, HUD, 1976.

Cabin Fever V

Human Factors

Although the physical features of a home are quite important in determining its minimum energy requirements for heating and cooling, the activities of its occupants are just as important.

Research studies have shown that families in identical townhouses, with the same number and kinds of appliances, did not use the same amount of fuel and electricity. Some families used half as much as others over a year's time.

Why so much difference? There are habits of energy use that vary from family to family--how many hours the TV is used; how high the thermostat is set; how windows are opened and closed or covered and uncovered; how carefully exterior doors are closed, and how often they are opened; how much lighting is controlled; how active people are (sedentary bodies require more heat); cooking, refrigeration, and freezing practices, etc. So human routines in daily living can make significant differences in energy consumption.

Researchers at Princeton University found that people in their sample community at Twin Rivers, NJ, cut their energy use significantly (13.4%) when they were given a hard goal (20% energy reduction) and regular feedback on their progress. Your family used 2 kwh less electricity yesterday than your daily average for the previous month.) Families given the same hard goal but no feedback also saved energy, but savings were much smaller (1.8%). Families given an easy goal (2% energy reduction) used more energy, more even than did a control group that wasn't asked to do anything.

Other recent studies show that people can provide their own feedback to help them save energy and money. Some buy devices to signal when outside air is cool enough that air conditioners can be turned off and windows opened instead. Others set themselves goals and read their own gas and electric meters two or three times weekly, charting their progress. Still others find monthly reminders (the utility bill) sufficient, especially if the previous year's bill for that month can be used for comparison.

Some families set themselves energy-consumption goals lower than recent use, and if the goal is met, put the money saved toward other energy-saving uses (bicycles or walking shoes or tickets to a concert, for examples). Others cooperate best when a public commitment is made. People who agreed to have their names mentioned in newspaper articles as persons who were attempting to conserve energy used much less energy over a year's time than others who also had agreed to conserve but were not named publicly.

Lowering the thermostat, covering windows with insulating draperies or shutters on cold nights and on hot summer days, using less hot water and being more conservative in the use of lights are personal actions that most people can do, without inconvenience, in the homes they live in now. Greater savigs require some changes in lifestyle and less dependence on mechanical things.

Reduced demand for energy would pay off several ways:

1. Short term: Dollar outgo for household energy will be less than if no conservation is practiced.

2. Long term: a) Utility companies will not need to build so many more new facilities, so their capital demand and customers' future bills will rise less than otherwise. b) Rates of air pollution, heat pollution, and consumption of non-renewable fuels would be slowed. c) More time and money would be available for development of solar and other renewable-energy technologies.

If enough people can see that saving energy assures us an easier transition to the future; if enough persons value what they do instead of what they have; if sharing is more important than getting; then our homes will be truly warm.

Resources:

"Energy Incentives" by Paul Stern, Psychology Today, April 1979.

Families in the Energy Crisis by R. Perlman and R. Warren; Ballinger Publishing Co., Cambridge, MA, 1977, $17.50.

Lifestyle Index by Anne Pierotti and A. J. Fritsch, from Citizens' Energy Project, 1413 K St. NW, 8th floor, Washington, DC 20005, $2.

Project Waste Hunt by Joanne Anderson, 1974, available free from the Citizens' Movement for Safe and Efficient Energy, P.O. Box 1538, Washington, DC 20013.

Social Aspects of Energy Conservation by M. Olsen and J. Goodnight, 1977, $9 from National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161, Stock No. PB 266029.

Activity Suggestions:

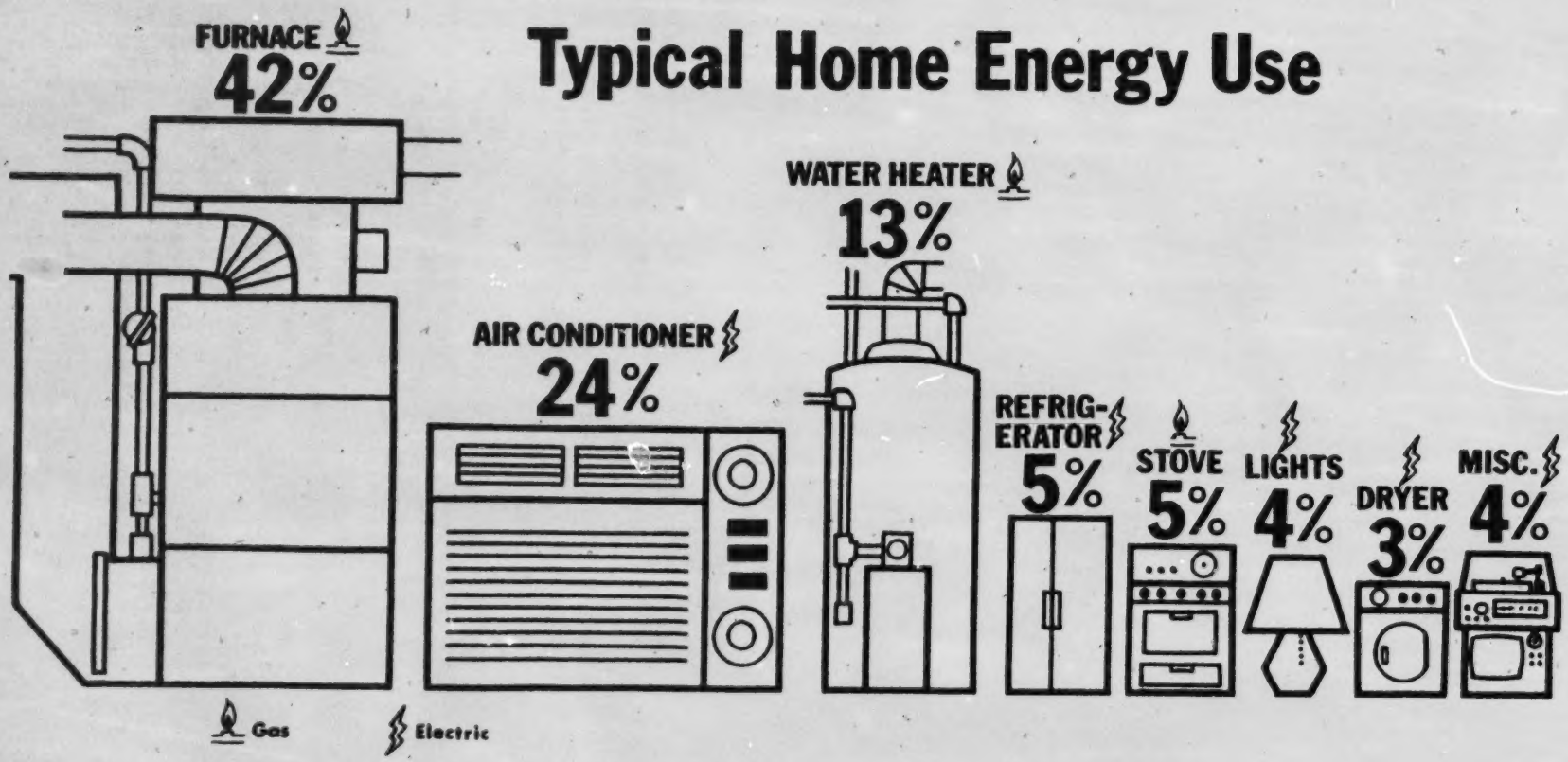
1. Have the class cooperate in generating a list of places in your community where energy and resources are shared by non-relatives. Examples may be parks, churches, religious communities, social groups, Y's and other athletic clubs, any kind of co-op, rental centers, laundromats, museums, libraries, schools. Assign a small group of students to visit or to gather information on each community site, its energy-related advantages and disadvantages, and an approximate number of the people it serves monthly or yearly. Look especially for energy-saving and energy-consuming features that can be attributed to people's activities, habits, preferences, and choices.

2. Use the information gathered in the previous activity as a basis for class discussion or for individual projects aimed at describing an ideal "community of the future" in which people conserve energy and resources more efficiently.

3. Invite a returned Peace Corps volunteer, a food co-op organizer, a baby-sitting co-op member, a religious community spokesperson, a hospital volunteer coordinator, an equipment-leasing businessman, or an insurance advisor to your class to discuss advantages and challenges of service-oriented work in an energy-limited world.

4. Have students monitor family fuel electricity use, keeping track of meter readings and/or purchases for a week or more. Then, with family cooperation, ask students to try to conserve energy for a second trial period of one week or more. Compare results and discuss effects of family-selected strategies for reducing waste. See the activity READING ELECTRIC METERS for worksheets and more details.

Typical Home Energy Use



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Data is derived from Patterns of Energy Consumption in the United States, U.S. Office of Science and Technology, January, 1972.

This graphic represents a "Typical Use" overall for the U.S. in 1970. Actual consumption patterns vary widely. New Mexicans, for example, rarely use airconditioning. Texans use more energy for air cooling than for heating. A typical Iowa household uses three to four times more energy for heating than for cooling. 65% of a customer's bill is usually spent for heating and cooling air according to an Iowa-Illinois Gas and Electric estimate (1979).

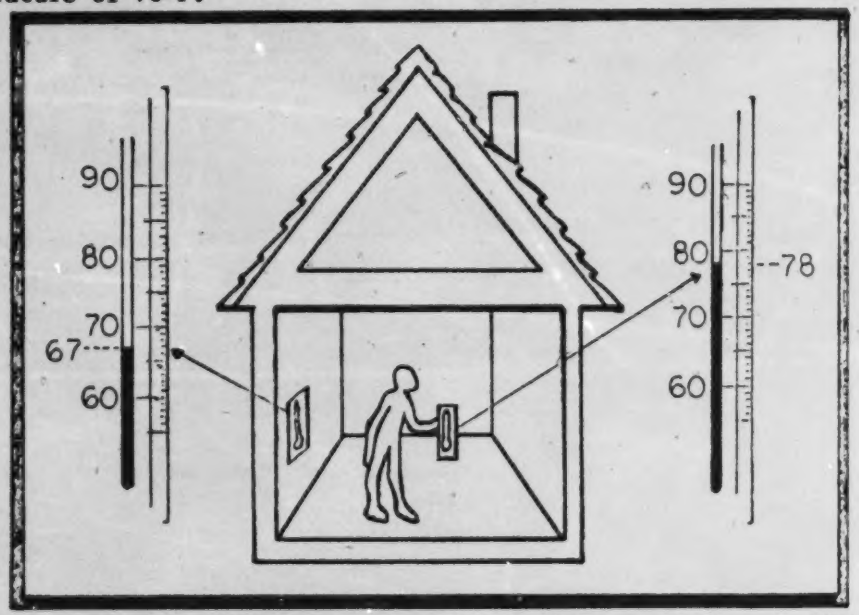
Checking Wall Insulation

Objective:

To determine the adequacy of wall insulation in a completed structure.

Directions:

During the heating or cooling season, when the heating or cooling equipment is operating, place a thermometer firmly against the inside surface of an exterior wall and another in the center of the room. It's easiest to hang the thermometer on a picture nail or hook on the wall, and place it in a chair in the middle of the room. Allow sufficient time for the temperatures to register and then record the two readings. If the difference between the two readings is greater than 5°F, the wall is probably not adequately insulated. The example illustrated below shows an exterior wall temperature of 67°F and a center of the room temperature of 78°F.



The next step is to determine the difference in the two readings: 78°F-67°F = 11°F. The difference is greater than 5°F; therefore, for this example, we would draw the conclusion that the wall may be inadequately insulated.

Now try this exercise at your house. You may wish to try it in several rooms with exterior walls.

Room _____

Outside wall thermometer reading _____
Center of the room thermometer reading _____

The difference between the readings:

_____ - _____ = _____
(higher reading) (lower reading) (difference)

Is the difference greater than 5°F?

Another place that poorly insulated buildings show uneven temperatures is at floors and ceilings. Warm air rises, so small differences between floors and ceilings (1-2°F) can be expected. But if floors are uncomfortably cooler, people are likely to turn up the thermostat and overheat the rest of the building. Insulation can help prevent such imbalances.

Put a thermometer on the floor and hang another near the ceiling in the room you want to test. Allow at least five minutes for the thermometers to register. Then read and record their temperatures.

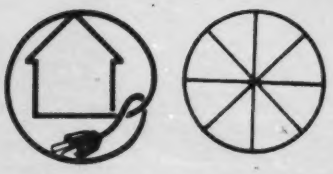
Room _____
Floor reading _____ Ceiling reading _____
The difference between the readings is _____
Is the difference greater than 5°F? _____
What can you say about adequate insulation in this structure?

Are there reasons other than inadequate wall insulation which might cause a difference in the temperature readings? _____ What might they be?

Suggestion:

Try this exercise in the classroom, gymnasium, and restroom in your school.

Activity adapted from Energy Conservation in the Home, An Energy Education/Conservation Curriculum Guide for Home Economics Teachers, U.S. Dept. of Energy, Prepared by Univ. of Tenn. Environment Center and College of Home Economics, Knoxville, TN. October, 1977.



Convenience and Energy

Objective:

To develop the awareness that many resources are depleted in quantity and quality in the name of convenience; that choices between essential needs and non-essential desires are often in conflict; that individuals can extend resource life by careful management.

Procedure:

Ask each student to check at home or the local supermarket for processed convenience foods that are family favorites. The student should list three or four items, weight of the packages, number of servings each provides, and current prices for the quantity specified.

The next day, tabulate these lists during classtime to determine the most often-used items. Determine which of them could be prepared at home using the basic ingredients. From these, select two or three which can actually be prepared in class for comparisons in cash outlays for equivalent servings as well as comparisons on overall quality and nutritional differences (if any) of the convenient vs. "scratch" prepared items.

Some questions you may want to consider discussing are suggested below. Select one or more that correlate with the specific instructional emphasis in your class.

Questions:

1. Were costs of preparing the food at home higher or lower (per serving) than if these items were purchased ready-to-eat from the store?

2. Did you consider the energy cost of using your range and/or water? If not, approximately how much would this add to the cost? Helpful data is available from your local utility companies.

3. Should the time spent (preparing these foods at home [human energy]) be considered in your comparison? Explain.

4. What kinds of energy and materials are used in processing and packaging the convenience foods you have been discussing?

5. Do any of these represent resources which must be conserved?

6. Can any of these materials be re-used?

7. Make a final list of the food items you have decided could be prepared more economically at home.

8. Make another list of food items that require no special preparations at all. Add an asterisk in front of those that can be raised on Iowa farms or gardens.

9. Identify all the energy inputs required to get your favorite processed food to you vs. the energy input required for putting an item from #8 into your diet.

Electricity for Fun, Convenience, Work

Please answer the following survey as honestly as you can. There are no right or wrong answers.

1. Check the column which best describes your attitude toward doing without the following electrical items. Even though some of these items may also be powered by natural gas or gasoline, assume an ALL ELECTRIC environment.

Item	Easily	With Some Difficulty	With Great Difficulty	Would Not Give This Up
radio				
stereo				
television				
air conditioning				
dishwasher				
clothes washer				
iron				
microwave oven				
stove				
refrigerator				
freezer				
lights				
electric mixer				
electric razor				
space heater				
toaster				
elevators				
hair dryer				
dehumidifier				
fans				
vacuum cleaner				
electric games				
blender				
electric blanket				
typewriter				
calculator				
dentist's drill				
telephone				
clothes dryer				
hot water heater				
garbage disposal				
power tools				
electric golf cart				

2. Just for fun, rate yourself by counting up the number of checks in the last three columns____(all but "easily").

   If there are ten checks or less, you could tolerate a rather Spartan independence of most electrical appliances. If you count 15 checks or less in the last three columns, your use of modern appliances is moderate. If you have 16 or more checks in those areas, you are quite dependent on electricity for your lifestyle. On the number line below, plot your dependency on electricity.

   What is your electricity attitude rating?

   ≤ 10 checks — Spartan; 11-15 checks — Moderate; ≥ 16 checks — Dependent

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

3. Which of the following jobs could you do adequately in your house without electricity? (Circle them.)

1.	cooking	6.	storing food in summer
2.	washing clothes	7.	storing food in winter
3.	drying clothes	8.	lighting
4.	washing dishes	9.	keeping warm in winter
5.	drying hair	10.	keeping cool in summer

4. In order to guarantee the continuation of those services which you find difficult or impossible to do without (see 2), it may be necessary for you to accept some of the following conditions. Let #1 represent the most tolerable cost of power usage and let #7 represent the least acceptable one. In which order would you accept:

   _____having no more than two children
   _____living within ten miles of a nuclear power plant
   _____possibility of food contamination
   _____occasional interruption of power
   _____increased cost of electricity
   _____severe air pollution
   _____shorter life span

Teacher's Guide to
Electricity for Fun, Convenience, Work

Background:

Of all forms of energy that Americans use, electricity may be the most controversial.

Hydroelectric plants do take advantage of a renewable resource and are both efficient and environmentally "clean" in operation. But most of them depend on man-made dams that alter the normal flow of water, sometimes with questionable effects. Dams themselves are subject to dangerous failures when "old" at 40 years.

Oil and coal-fired plants can visibly pollute the air. Nuclear-powered generating stations require exacting designs and highly trained people to keep them in safe operating condition. Surplus heat released to the environment is another effect of power generation that is wasteful and may do long-term damage. These "costs" are often hidden, as is the cost of dismantling outdated plants and equipment. But the ever-rising expenses of building additional generating stations (in anticipation of increasing usage of electricity) as well as necessary replacements for obsolete facilities shows up in everyone's electric bills.

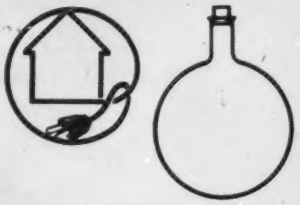
Electricity still quietly serves us in many essential ways, but its growing price tags, both personal and environmental ones, have stimulated many persons to consider which of its uses may be trivial, which are merely convenient, and which are invaluable.

Procedure:

The following exercises are intended to give young people some awareness of their own preferences, conveniences, and dependencies. There are no "right" or "wrong" answers. Duplicate the following pages for individual student responses. When summarized, results of these self-judgments should provoke much discussion.

An extended activity would be to mark with an asterisk all those items in Exercise 1 that grandparents or older neighbors enjoyed 40 years ago. Then ask students to note whether these uses of electricity are considered easy to do without or essential today.

Invite a senior citizen to tell the class about life without so many appliances and conveniences. What was his/her work like then? How did he/she have fun? What recreation, convenience, and work experiences today represent the biggest changes from the first half of this century?



Food - Energy Conservation

Background:

Processed foods cost energy for preparation, for packaging, and sometimes for storage as well. Some processing is unavoidable, however. Many must be specially preserved for use after the growing season ends. Others must be treated to stay edible during prolonged transportation and storage before reaching consumers. Special packaging that adds to the "energy cost" of some foods may keep out moisture and insects or may be chosen primarily for attractiveness, convenience, and/or familiarity to the consumer.

What can be done to reduce food-related use of energy? Note that typical processed foods usually involve transportation and storage costs, packaging costs, food-chain losses, and additional home-energy use.

The first energy premium, transportation, is reduced whenever fresh produce is grown at home. Even if commercial practices are used in the home garden, about half of the energy cost to put fruits and vegetables on the table is saved by the gardener. If hand-spading, composting and non-chemical pest control practices are used as in "organic" gardening, then even more energy savings are likely.

Avoiding some highly-processed foods, frozen specialties in particular, can also reduce reliance on commercial energy. TV dinners and their packaging, for example, typically take 4.43 KWH* each to process--much more than if individual items were cooked from basic ingredients. By comparison, a 14 ft. standard refrigerator-freezer requires about 3.3 kwh daily for its operation; a microwave oven typically uses 1.5 kw during 60 minutes of operation while a conventional electric oven uses about 3.8 kw during that time.

Packaging is usually a major energy "cost" of bringing food to the consumer. Fast-food restaurants often put multiple wrappings on sandwiches to be eaten immediately. Smaller grocery containers require more packaging material per unit of contents than do larger containers. Paper bags and glass bottles can be reused and metal cans can be recycled, but seldom are. Consumers can help reduce these energy extravagances by buying more bulk and unpackaged foods; by patronizing co-op stores which allow customers to reuse their own bags and containers, by buying beverages in returnable bottles only. (Most soft drinks have two to three times as many Calories invested in the container--not including transportation and cold storage energy consumed--as is contained in its surgary contents.*)

**Data from Energy and Food, by Pierotti, Keeler and Fritsch, Center for Science in the Public Interest, 1977.*

Food-chain losses come with every conversion of energy from one life-form to another. In general, the shorter the chain, the greater the percentage of solar energy is available to the human consumer. Plant protein requires less energy input than does animal protein, so whole grains and legumes (beans, lentils, peas) when substituted for meat or used as meat extenders conserve energy. Milk, cheese, eggs, fish, and poultry require < 20% of the energy input required for beef cattle to produce the same amount of protein. So more "efficient" eating would usually mean menus low in grain-fed beef, high in vegetable and animal produce substitutes.

Energy costs do not stop when we carry groceries home. In fact, storing and preparing food at home requires more energy than any other single step in the long chain from solar energy to human energy. Ovens, refrigerators, and freezers plus a host of smaller appliances, some of which (coffeemakers and toasters for examples) are high energy consumers, are part of most human kitchens. Their use contributes to the nine to ten Calories of energy spent by U.S. citizens for every Calorie of food put on the table, a record of inefficiency among developed nations.

Resources:

Energy and Food by Pierotti, Keller, and Fritsch, 1977. This technical report on energy used in production, processing, delivery, and marketing of selected food items is available for $6.90 to educators from Citizens' Energy Project, 1110 6th Street NW, #300, Washington, D.C. 20001.

Lifestyle Index by Pierotti and Fritsch, 1977. Text, tables and data sheet provide provocative invitation for individual assessment of energy used in everyday life. Send $2 to Citizens Energy Project, 1110 6th Street NW, #300, Washington, DC 20001.

Diet for a Small Planet by Francis Lappe, a Ballantine paperback cookbook, includes both rationale and recipes for saving energy by eating lower on the food chain.

Current articles in Organic Gardening, Mother Earth News, other magazines with practical living tips.

Activity Suggestions:

1. Try to trace the energy route of today's school lunch, from the sun to the student consumer. How many steps are involved? Can any of them be eliminated?

2. Plan a series of menus involving least-possible energy use to put the food into edible form.

3. Identify the items with highest-energy input on restaurant menus and the items with the least energy and preparation requirements. Consider transportation, storage, packaging, cooking and serving requirements. Can balanced diets be planned by eliminating the most energy-intensive items and increasing use of the least energy-intensive ones?

4. Survey your local grocery store with a critical eye. Report your observations in any form that answers the following questions: Which categories of food require the most energy at that site? Is the cost of that energy use within the store reflected in the price of those items? What energy-saving features are incorporated into the design and operation of the store? Can you identify areas needing improvement? What were people buying when you visited the store? (Approximate percentages of purchases for basic fresh foods that need no further energy input; raw foods that must be cooked before eating; processed ready-to-eat foods that require refrigeration and those that do not; processed foods that require heating or cooking before use.)

5. Visit a food co-op or a food discount store. What is different about their groceries, physical facilities, and method of distribution? Identify any energy demands and energy savings in these operations.

6. Plant a vegetable garden; investigate both energy and economic savings by comparing net yields of your produce vs. usual store purchases. Record keeping is important if you hope to make fair comparisons.

7. Explore secondary use possibilities for food packages. What is being done now with the paper, plastics, metals, and glass leftover from food purchased--by individuals at home, by food distributors like your local grocery, by city sanitation crews? What are the alternatives for disposal? Which would be better for conserving energy and other natural resources?

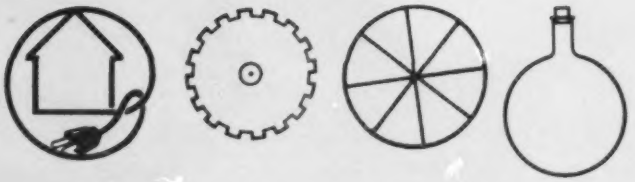
8. Do a controlled experiment on cooking in covered vs. uncovered containers.

9. People in some European countries use thermos bottles to keep coffee hot all day. Americans often rely on uninsulated electric pots or on coffee machines which use about 1.4 kw for every hour of keeping coffee hot.

   Danes are fond of "hay boxes" or tightly insulated bins into which a preheated potful of unfinished stew, soup or pot roast (for examples) can be left simmering for hours, completing cooking without additional energy expense.

   Iced tea lovers the world over have learned that loose tea or tea bags (2 tsp. or 2 bags to a quart) put into a glass container of water will slowly brew into a non-bitter tea. The only extra investment is time--two to three hours of exposure to the Sun will do it, or about 12 hours in a dark corner. The bonuses are in energy savings, costs, and improved flavor.

   The above examples of "passive" energy savers in food preparation. Look through energy publications, home and food magazines, and cookbooks and/or talk to older people in your community to see how many other savers in food preparation you can list. Exchange ideas with classmates. Compile a composit list for the class. Consider publishing such a list for your parents, or in the local newspaper, or by sending your treasury of energy-reducers to a popular home-centered magazine.



Home and Schools' Energy Efficiency

A project to monitor energy use of your school building and compare it to an average one for your area is a very practical and effective teaching device. Not only that, it can involve the community outside the classroom (schoolboard, taxpayers, parents) which is keenly interested in energy economy as well as the entire staff of the school itself.

Such a project involves students in learning some heat transfer theory, making practical measurements, and doing calculations with guidance from the teacher. They can then apply these techniques to an energy assessment of their own homes.

All the facts you need and step-by-step instructions have been published by Dr. Dale Mordue of Mankato State in his booklet, "Energy Conservation: A Classroom or Do-It-Yourself Project." The booklet is available from Dr. Doris Simonis, Science Education, University of Iowa, Iowa City, IA 52242 for $1.25. Or you can mail your request and $1.50 for a postpaid copy from Dr. Dale Mordue, MSU Physics Department, Mankato, MN 56001.

Several Iowa teachers have had experience with Dr. Mordue's program and they may be helpful resource persons for this recommended activity. Their names and locations follow:

W. D. Ackerman, Hoover High School, Des Moines, IA 50310

D. Lester Carter, Pella High School, Pella, IA 50219

Stephen Dikkers, Guttenberg Jr.-Sr. High School, Guttenberg, IA 52052

Donald E. Liefeld, Central Lyon Sr. High School, Rock Rapids, IA 51246

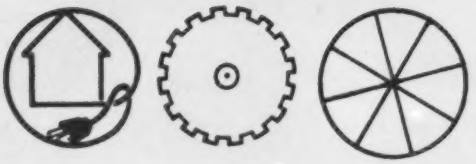
Larry Nelson, Lakota High School, Lakota, IA 50451

Robert G. O'Connell, Wahlert High School, Dubuque, IA 52001

Roger L. Park, Wayne Community High School, Corydon, IA 50060

Glen Peterson, Le Mars High School, Le Mars, IA 51031

Dwight Williamson, Clear Lake High School, Clear Lake, IA 50428



On the Road to Energy Savings

Introduction:

It is estimated that, if just one gallon of gasoline were saved each week for every automobile in the country, we'd save about 5.6 billion gallons of gasoline in a year. That's about eight percent of the demand created by all our passenger cars. It's easy to see that the effort of each individual can make a difference.

By doing this project, you can find out how much of a difference you can make. You'll learn how much energy your family is using for transportation at present and also how much you can save when you try to conserve energy.

Time Required:

This activity will take you two weeks to complete.

Brief Description of the Project:

During this project you'll be keeping track of the odometer readings (the odometer counts the miles traveled) of one or more of your family's cars, as well as the gallons of gasoline used. You'll first establish a "baseline" week to see how many miles are traveled and how much gasoline is used in a normal week when no attempt is made to cut down. You'll follow that by a "conservation" week where you'll make an all-out effort to reduce the number of miles traveled and increase miles per gallon. Of course, during the conservation week, you'll need to involve all the drivers in your family in the effort to save.

Here's What You Should Do--A Step-By-Step Procedure

Getting Family Cooperation:

If your family has more than one car, you'll want to involve as many cars as possible in this project. For each car involved in the project, someone should be assigned to make odometer readings and record gallons of gasoline purchased. This should logically be the person who buys the gasoline.

The entire family can be involved in going over the booklet entitled "Tips for Energy Savers" from DOE. As a group, you can decide what each family member can do to contribute to the overall savings. A large percentage of a family's budget goes for transportation. Therefore, you'll want to emphasize the economic benefits of conserving in order to convince other family members to participate in the project.

The Trip Log:

Keep a trip log in each car involved in the project. Each time someone takes the car out on the road, they should record the date, the purpose of the trip and the miles driven. At the end of the baseline week, the data collected on this form will be very useful in planning for the conservation week. You and your family should study the data and develop a plan to reduce the number of trips and miles driven during the conservation week. Get each driver to agree to the plan.

The First Odometer Reading:

Find out from your teacher what day you should begin the project. To begin this project, your car's gas tank must be full; otherwise, proper calculations regarding gasoline mileage cannot be made. Therefore, start the project at the gas station. After the tank is full (there is no need to record the number of gallons this time) make a note of your odometer reading (odometer reading #1) on the Recording Form. (You'll need one of these forms for each car involved in the project.) Also, note the date and time of day of this first reading. You'll want to make odometer reading #2 on the same day of the week and at the same time of day exactly one week later.

The Baseline Week:

The week following this first odometer reading is your "baseline" week. The baseline week is used to establish how many miles are traveled and how much gasoline is used in a normal week. During this week, you should make no attempt to institute any new conservation procedures. You can continue to practice those which are already in effect.

All that you will need to do during this week is to record the number of gallons purchased each time you buy additional gasoline. There is room on the recording form for three additional purchases during this week.

The Second Odometer Reading:

Exactly one week after the first odometer reading and at the same time of day (timing is important for meaningful interpretation of results) you should again fill the car's gas tank and record the odometer reading (odometer reading #2). This time you should also make a note of the number of gallons of gasoline purchased. Use the recording forms.

The Conservation Week:

After your second odometer reading is completed you and your family are now ready to begin the "conservation" week. During this week you should do everything possible to reduce the number of miles each automobile is driven and also to increase miles per gallon. Use this "Tips for Energy Savers" booklet as a guideline, but don't be limited by it. If you can think of other ideas, try them out.

If you need additional gas during this week, make sure you note on the recording forms the number of gallons purchased each time.

The Third Odometer Reading:

Exactly one week after the second reading (this should be on the same day of the week and at the same time of day as the two previous readings) take the final odometer reading and note it on the recording form. You should also fill your tank at this time and make a note of the number of gallons of gasoline required.

Using the Odometer to Determine Miles Traveled:

The odometer of your car gives a total, cumulative reading of mileage. To find out how many miles you traveled during a given period of time (for instance, one week), you must compare readings made at the beginning and end of that period.

Study the example below:

First Saturday odometer reads	15,550
Second Saturday odometer reads	15,800
How many miles were traveled?	15,800
	- 15,550
	250 miles

Note: The rightmost dial of your odometer indicates tenths of a mile and can be disregarded for this project.

Computing Miles Per Gallon:

Miles per gallon is the number of miles you get from one gallon of gasoline. Basically, it's an indication of the fuel efficiency of your car.

To compute miles per gallon, you must keep a record of the amount of gasoline added to your tank and the odometer reading at each fill-up. MPG is obtained by dividing the miles traveled since the previous fill-up by the gallons added at the last fill-up. (In other words, you divide the number of miles driven between fill-ups by the number of gallons of gasoline used.) Keeping track of miles per gallon is one way to detect the need for a tune-up when your mileage drops.

Study the example below:

Miles traveled	250
Gallons of gas used	10

Miles per gallon = 250 ÷ 10 = 25 mpg

Recording the Results:

Using the Computation Forms, compute your total miles traveled for the baseline week and the conservation week, and also compute your miles per gallon for each week. Then, find the difference between the two weeks--hopefully a savings in miles traveled and an increase in miles per gallon. If your usage and mileage stayed the same or did not improve, try to figure out why. The discussion suggestions may help you.

Reporting Back to the Class:

Be prepared to report the results of this project to the class. Compare your experiences with those of others. Again, the discussion questions will help you analyze your results.

Where to Go From Here:

Hopefully, you and your family have learned something valuable as a result of this project. You may want to consider implementing many of the conservation procedures on a permanent basis. Plan to save energy and money.

Recording Form

(Use a separate form for each car involved in the project.)

Odometer reading #1 _____	This reading is done at the beginning of the Baseline Week after filling the gas tank. There is no need to record gallons of gas for this filling as it is not needed for the computations.
A___gallons___cost per gallon B___gallons___cost per gallon C___gallons___cost per gallon	If you purchase additional gas during the Baseline Week, record the number of gallons here, and the cost.
Odometer reading #2 _____ D___gallons___cost per gallon	This reading is done at the end of the Baseline Week-start of the Conservation Week after filling the gas tank. Gallons of gasoline and the cost should also be noted for this filling.
E___gallons___cost per gallon F___gallons___cost per gallon G___gallons___cost per gallon	If you purchase additional gas during the Conservation Week, record the number of gallons here, and the cost.
Odometer reading #3 _____ H___gallons___cost per gallon	This reading is done at the end of the Conservation Week after filling the gas tank. Gallons of gasoline and the cost should also be noted for this filling.

Computation Form

(Use a separate form for each car involved in the project)

STEP 1: THE BASELINE WEEK

COMPUTING MILES TRAVELED

Odometer reading #2	- Odometer reading #1	= Miles traveled

COMPUTING MILES PER GALLON

Miles traveled	÷ Total gallons of gas used (add together all fill-ups under A, B, C and D)	= Miles per gallon

---

STEP 2: THE CONSERVATION WEEK

COMPUTING MILES TRAVELED

Odometer reading #3	- Odometer reading #2	= Miles traveled

COMPUTING MILES PER GALLON

Miles traveled	÷ Total gallons of gas used (add together all fill-ups under E, F, G and H)	= Miles per gallon mpg

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STEP 3: SAVINGS

COMPUTING SAVINGS IN MILES TRAVELED

Miles traveled first week	- Miles traveled second week	= Savings in miles traveled

COMPUTING INCREASE IN MILES PER GALLON (MPG)

mpg 2nd week	- mpg 1st week	= Increase in mpg

Trip Log

Keep this trip log in the car and make a record each time you take the car out on the road. You will need one of these forms for each car involved in the project.

Baseline Week			Conservation Week		
Date	Purpose	Odometer Reading	Date	Purpose	Odometer Reading

Discussion Questions:

Congratulations if your computations indicate a savings in miles traveled and/or an increase in miles per gallon. If things stayed pretty much the same during the two weeks, or if they got worse during the second week of the project, can you think of any reasons why this occurred? Some things you might consider are as follows:

Family was already energy-conscious--no room for improvement.
Family took a long trip during the second week.
It was your parents' turn to drive for the carpool during the second week.

Keep in mind that, if you had a savings, it could have been that things of this type were operating in your favor.

Use a separate sheet of paper to answer the following questions:

1. Regardless of your results, write a short paragraph describing any unusual circumstances which may have affected the outcome.

2. If you were successful in reducing miles traveled and/or increasing miles per gallon, specify which conservation effort you feel is responsible for this result.

3. Were there any major changes in your family's life style during the conservation week? (For instance, your parents joined a carpool; or you walked, rather than drove, to school, etc.) Please describe.

4. Based on current gasoline prices, compute the cost of the gasoline used during the baseline week and the conservation week. These amounts can be multiplied by 52 to find out yearly costs with and without conservation.

5. Check the owner's manual in your car to determine vehicle weight, number of cylinders and size of engine (cubic inches). Also, make a note of any optional equipment the car has. How do you think these factors affected your conservation attempts?

6. Does your family plan to continue any of the conservation practices initiated during the second week of the project? If so, which ones?

7. Which conservation practices will not be continued, and why not?

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Teacher's Guide to On the Road to Energy Savings*

During this activity, students will keep records of odometer readings and gasoline consumption for as many of their family's cars as possible. They will be asked to establish a "baseline" week to determine how many miles are traveled and how much gasoline is used in a normal week when no attempt is made to cut down. This will be followed by a "conservation" week where attempts are made to reduce miles traveled and increase miles per gallon. The entire family is asked to participate in the effort.

After completing this project, students should:

1. Know what an odometer is and be able to compute miles traveled.
2. Know how to compute miles per gallon.
3. Know how many miles their family travels and the gasoline mileage their car gets in a "baseline" week as compared to a week where they make an intensive effort to conserve, as well as the cost factors involved.
4. Be familiar with various energy conservation procedures for transportation.
5. Have a positive attitude toward conserving energy.

Suggested Procedure:

Two months ahead of classtime, order bulk copies of the free booklet, "Tips for Energy Savers" from U.S. DOE, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

The project can be introduced with a lesson on odometers and how to compute miles traveled and miles per gallon. The curriculum package provides complete instructions for this purpose.

The project can be explained by going over the "Student Instructions" with the class. Time should also be spent going over the "Tips for Energy Savers."

During the first class meeting after the students do the initial odometer reading, time should be allotted to answer questions and straighten out problems students might be having with this part of the project.

As students approach the conservation week, a class discussion of their plans for that week and strategies for involving other family members would be very helpful. The trip logs for the first week could also be discussed.

**This activity was originally prepared by Nancy J. Leedom for the Youth Energy Project of the Michigan Department of Commerce.*

Finally, when the project is completed, several class periods can be devoted to interpretation and discussion of results, using the "Discussion Questions" in the curriculum package as a guideline. Students should be encouraged to share with each other their results and their experiences during the project. A summary of individual results on a bulletin board would be a good reinforcer for energy saving behavior.

Related Activities by Type of Class:

These activities are optional. They are suggested as a means to reinforce what is learned by doing the project. They are also designed to suggest how the project might fit into an "energy unit" in your class.

Language Arts, English and Speech

1. Have students write an essay or give a speech persuading others to change their driving habits to conserve fuel by reducing miles traveled and attempting to increase miles per gallon. The best essays could be submitted to the school or local newspaper. Other topics for essays and speeches: "Advantages of the 55 mph speed limit"; "Advantages and disadvantages of small cars."

2. Have students research and give a "how to" speech on car maintenance or tips on buying a new car.

3. Have students develop a series entitled "Energy Tip of the Day" to be broadcast along with daily school announcements.

4. Have students develop an energy conservation newsletter for transportation or have them develop and tape short energy conservation "commercials".

Mathematics/Science

1. Have students graph their miles traveled, gasoline usage and miles per gallon for the two weeks of the project.

2. Students could compute average usage for a family, group results and community results.

3. To demonstrate the importance of car pooling, students could learn how to compute "passenger miles per gallon" (pmpg), according to the following formula:

   pmpg = Number of passengers x miles per gallon

Example: Car with 3 passengers getting 20 mpg gets
3 x 20 = 60 pmpg

Bus with 30 passengers getting 6 mpg gets
30 x 6 = 180 pmpg

Art

1. Have students prepare a bulletin board display for some prominent location in the school. Use the "Tips for Energy Savers" for topic ideas.

American History/Social Sciences/Economics

1. Present students with the following hypothetical situation: "Suppose that the federal government decided on a policy of conserving gasoline by reducing the number of automobiles in this country." Ask them to come up with proposals for implementing such a policy, including who would be affected and how the policy would be enforced. Ask them to list some possible consequences of such action.

2. Have students report on the gas rationing program during World War II. They should answer the following questions: How did it work? What were some of the problems? Could the same system be used today?

3. Have students write an essay on the relationship of income and personal transportation. The essay should also deal with the idea of the car as a "status symbol".

4. Have students investigate mass transportation systems in other cities and come up with a plan of their own to improve their local system.

Home Economics

1. Students could find out what percentage of the family budget goes toward transportation energy. (25% was the national average in 1979.)

2. Ask students to discuss how "giving up" their family cars could affect their life-style.

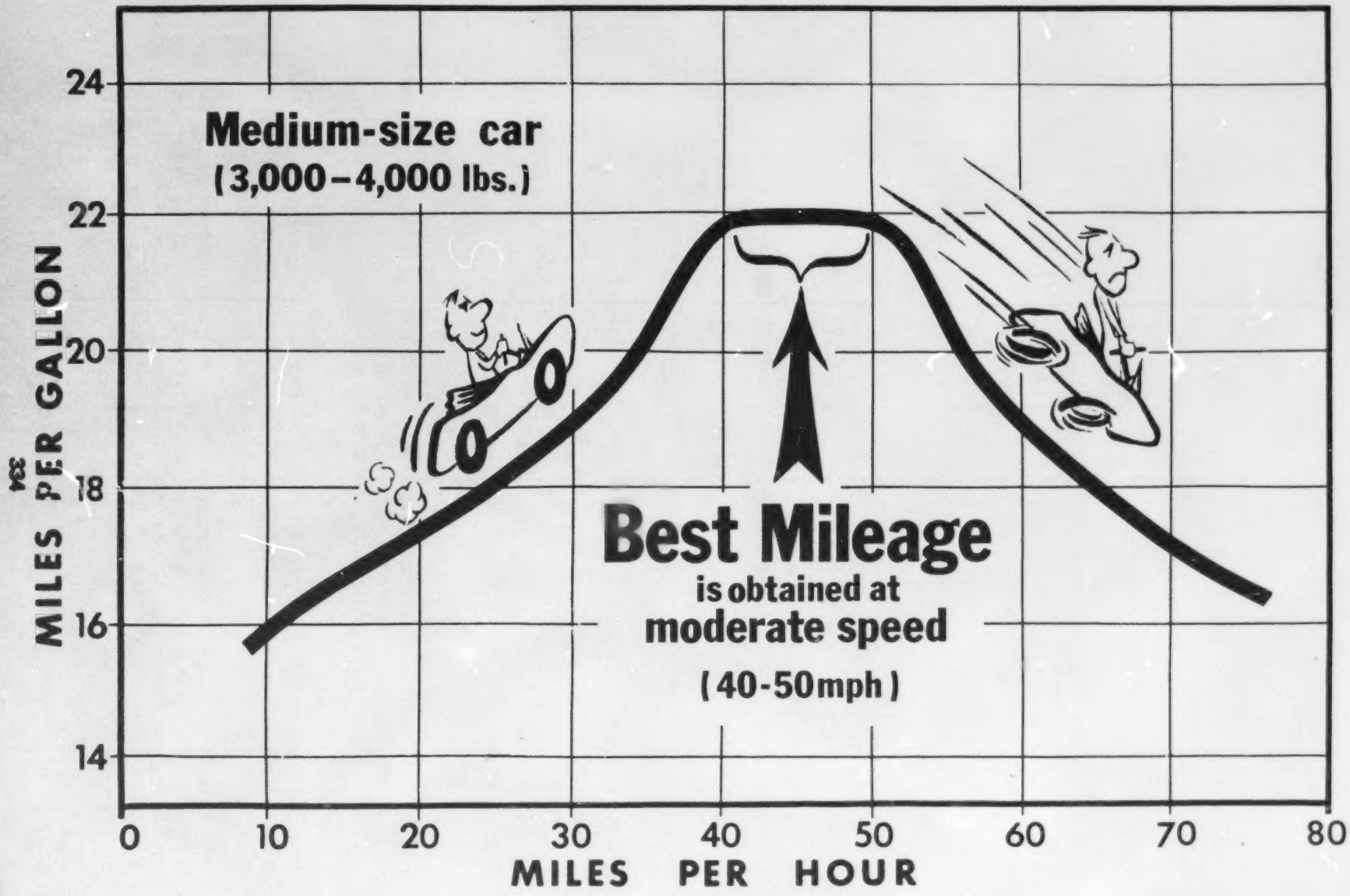
3. Students could devise with a car-pooling campaign for those students and teachers who drive to school. Included in this should be a list of the conditions which must be met for car pools to succeed.

Driver Education

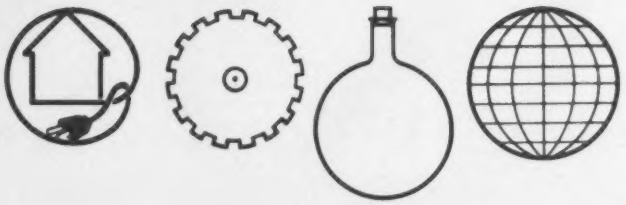
1. Students could be assigned to groups which would research the major topics of the tips booklet related to cars. They could elaborate on these topics and also suggest with additional ideas which they would report back to the class.

2. Obtain a copy of the "EPA/FEA Gas Mileage Guide" by writing to Fuel Economy, Pueblo, CO 81009. Have students compare their miles per gallon during the project to the estimates in this guide.

3. Ask students to research a paper on energy-saving innovations in automobile design. They could investigate electrically powered cars, as well as newly popular engine types like the diesel. The paper should address the question of whether these innovations are the answer to our energy problem.



Data from American Automobile Association.



Reading Electric Meters

On some wall of your home--basement, garage, or most often outside--you will find an intricate glass-enclosed device. If you are like most people, you seldom pay any attention to it. Nor do you need to, for modern electric meters perform their job so accurately and reliably that you need never be troubled. But, every month or so, a person from your electric utility company comes to see it, and later you are billed for the exact amount of electricity used.

Meters Measure Electricity. Through your meter's glass enclosure, you can see a revolving aluminum disk and a series of dials and pointers, or digital numbers. Without explanation, they don't make much sense, but they are really quite simple.

The amount of electricity you use determines the speed at which the disk moves. The more electricity you use, the faster it turns. Each revolution represents a portion of an electric energy unit called watt-hour. This watt-hour measurement is transferred from the disk through a series of gears to the digital numbers or pointers on the dials.

Just What Is A Watt-hour? Every hour a 100-watt light bulb burns, it uses 100 watt-hours of electric energy. Since a watt-hour is such a small unit of energy, your electric utility company uses a unit equal to 1,000 watt-hours--a kilowatt-hour--to measure the amount of electricity used.

What Makes Your Meter Disk Turn? There are two sets of connections which cause your meter to register: (1) the amount of current flowing into your house, and (2) the pressure or voltage at which the current is flowing.

Electric current is like water flowing through a pipe. The rate of flow of electrons through a line is measured in amperes. Pressure is the force that pushes electric current through the lines, measured in volts. To determine the electrical power (watts) used, multiply amperes of current by volts of pressure. Your electric bill is stated in kilowatt-hours.

Clock-Like Meter Accuracy. Friction inside the meter is all but eliminated with the use of a magnetic-suspension system which uses a magnetic field to float the disk and its shaft in air. To help maintain accuracy provided by magnetic suspension and other design features, the meter is sealed with filters which keep its interior free of dust and other contaminants which can cause inaccurate meter registration.

This student activity was taken from Environmental Education Strategies for Wise Use of Energy, Division of Science Education, North Carolina Department of Public Instruction, February, 1974.

Your Meter--A Small Motor. Your meter is basically a small induction motor run by magnetic forces created by electricity in a set of coils. The voltage coil is a winding of wire connected to the power supply lines. The current coil is a winding of wire connected with the household wiring. When current passes through these coils, the disk is forced to turn at a speed exactly proportional to the number of watts (amps x volts) of electrical power being used.

Meter Progress To Meet Your Needs. Meters have changed a great deal in the last 20 years. They have had to. Television, electric heating, more lights, freezers, air conditioners, water heaters, and other new appliances have more than quadrupled the average family's consumption of electric power. Twenty years ago a meter rated at 600 watts was enough to meet average household requirements. Today's meters are capable of handling up to 48,000 watts.

How To Read Your Kilowatt-Hour Meter. The kilowatt-hour meter is an instrument used to measure electrical energy consumed by a customer.

Two types of meters used by the power companies are the digital- and dial-type meters. The digital meter is read directly from left to right as shown in Figure 1. Readings on some digital meters are obtained by multiplying by ten.

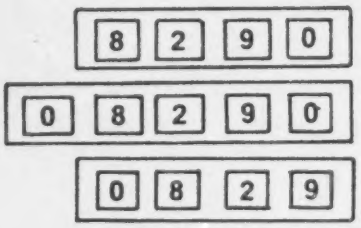


Figure I - Digital Kilowatt-Hour Meters

Most meters have four or five dials (see Figure II). The figure above each of the dials indicate the number of kilowatt-hours (kwh) registered by the meter during the time that the hand on that dial makes one complete revolution. So, when the hand on the right-hand dial has passed from one figure to the next, 1/10 of 10 kwh, or 1 kwh, has been used.

Be sure to read the meter "backwards"--from right to left--and remember to read the smaller of the two numbers between which the pointer on the dial is standing. This is very important.

Note that the pointers of the 10 and 1,000 dials rotate clockwise and counterclockwise on the 100 and 10,000 dials. During the time that the pointer on any one dial is making a complete revolution from 0 to 0, the pointer on the next dial to the left will pass from one figure to the next. Therefore, although a pointer on one dial may appear to have arrived on a given figure, that figure should not be read unless the pointer on the dial to the right has reached or passed 0.

For example, in Figure II, the pointer on the 1,000 dial looks as if it is on the 5, but you should read that dial "4" because the pointer on the 100 dial, to the right, has not made a complete revolution to 0. The correct reading is shown under the dials.

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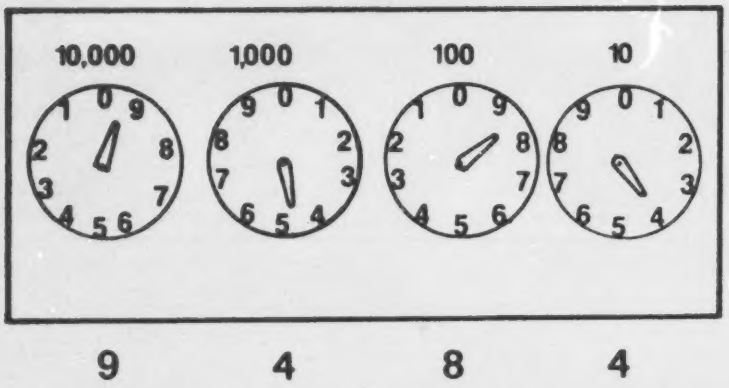

Figure II - Dial Kilowatt-Hour Meter

Kilowatt-Hour Record

(Student Activity Sheet)

Read your kilowatt-hour meter at home and record the reading. A. _____

Read one week later and record the reading. B. _____

Subtract B from A to determine kwh used during the 1st week of your experiment. C. _____

During the 2nd week, encourage your family to conserve all the electricity possible. At the end of your 2nd week, again read the meter and record. D. _____

Subtract D from B to determine kwh used during the 2nd week of your experiment. E. _____

Subtract E from C to determine how much electric energy your family saved over the previous week. F. _____

1. Were you successful or did you use more electricity?

2. If you used more, can you explain why?

3. Why would someone with an electrically-heated home have to consider the temperature during the two weeks?

4. List all the energy-saving steps your family took.

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HOW MUCH GAS OR ELECTRICITY DO WE USE?

Name _____

Date _____ Time _____ READING _____

Date _____ Time _____ READING _____

TRY TO SAVE ENERGY!

Date _____ Time _____ READING _____

Date _____ Time _____ READING _____

How Much Electricity Appliances Use

The following data are based on normal usage of appliances named.

Appliance	Average Wattage	Estimated Kilowatt Hours Consumed Annually
Food Preparation		
Blender	300	1
Broiler	1,140	85
Carving Knife	92	8
Coffee Maker	894	106
Deep Fryer	1,448	83
Dishwasher	1,201	363
Egg Cooker	516	14
Frying Pan	1,196	100
Hot Plate	1,200	90
Mixer	127	2
Oven, Microwave (only)	1,450	190
Range		
with oven	12,200	1,175
with self-cleaning oven	12,200	1,205
Roaster	1,333	60
Sandwich Grill	1,161	33
Toaster	1,146	39
Trash Compactor	400	50
Waffle Iron	1,200	20
Waste Dispenser	445	7
Food Preservation		
Freezer (15-21 cu. ft.)		
chest type, manual defrost	*	1,320
upright type		
manual defrost	*	1,320
automatic defrost	*	1,985
Refrigerators/Freezers		
manual defrost, 10-15 cu. ft.	*	700
automatic defrost, 16-18 cu. ft.	*	1,795
automatic defrost, 20 cu. ft. & up	*	1,895
Laundry		
Clothes Dryer	4,856	993
Iron (hand)	1,100	60
Washing Machine (automatic)	512	103
Washing Machine (non-automatic)	286	76
Water Heater	2,475	4,219
(quick-recovery)	4,474	4,811

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Appliance	Average Wattage	Estimated Kilowatt Hours Consumed Annually
Comfort Conditioning		
Air Cleaner	50	216
Air Conditioner (room)	860	860**
Bed Covering	177	147
Dehumidifier	257	377
Fan (attic)	370	291
Fan (circulating)	88	43
Fan (rollaway)	171	138
Fan (window)	200	170
Heater (portable)	1,322	176
Heating Pad	65	10
Humidifier	177	163
Health & Beauty		
Germicidal Lamp	20	141
Hair Dryer	381	14
Heat Lamp (infrared)	250	13
Shaver	15	0.5
Sun Lamp	279	16
Tooth Brush	1.1	1.0
Vibrator	40	2
Home Entertainment		
Radio	71	86
Radio/Record Player	109	109
Television		
black & white		
tube type	100	220
solid state	45	100
color		
tube type	240	528
solid state	145	320
Housewares		
Clock	2	17
Floor Polisher	305	15
Sewing Machine	75	11
Vacuum Cleaner	630	46

**Figures not available.*

***Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit.*

Source: Edison Electric Institute

Teacher's Guide to Reading Electric Meters

The purpose of having students learn to read electric meters to to give them an opportunity to practice conservation and to see the results as measured by a meter.

The activity calls for three meter readings over two weeks' time. It may be more practical to ask for daily readings made at the same hour each time. This would provide more practice and an accurate record for comparing daily usage, such as weekdays vs. weekends.

You may wish to ask the local power company whether it could provide a used meter for demonstrations. Or you may ask the school custodian to show you where the building's meters are and, if the location is convenient, use them for examples and for readings also.

A student activity sheet and a sample worksheet showing meter dials have been included for your convenience. The blank dials can be used for practice or for test items.

Key concepts to be emphasized in this activity are:

1. A kilowatt is a measure of electricity; it is 1000 watts of electricity; it is the amount of electricity used by lighting ten 100 watt bulbs for one hour.
2. Conservation efforts have measurable effects on consumption.
3. Reduced consumption means savings on utility bills.
4. What people do makes a difference. Rate of use of energy resources will determine how long supplies last.

Extended Activity:

This energy lesson can be extended to include reading gas meters and fuel oil bills and to keeping tract of gasoline purchases. Students may then be able to total their direct home or school use (per day or per month) of commercially-supplied energy. Some conversions may be necessary in order to make figures comparable:

Natural gas--cu. ft./day x 260 Calories/cu. ft. = Cal/day
(based on typical content 1,030 BTU/cu. ft.)

Fuel Oil--gal/day x 34,000 Cal/gal = Cal/day
—barrels/day x 1,400,000 Cal/bbl = Cal/day

Gasoline--gal/day x 32,000 Cal/gal = Cal/day

Electricity--kwh/day x 860 Cal/kwh = Cal/day

Going a step further, recognize that getting energy to the home also costs energy. Mining, refining, and transporting fuels also requires energy use. You can approximately account for that cost by multiplying natural gas, fuel oil, and gasoline Cal/day x 1.1 to get a new Cal/day total.

Electricity generated from fossil or nuclear fuels is more fuel-expensive to produce than are primary energy sources. For every three units of fuel burned, only one unit of electricity is realized; the balance is released as waste heat. To approximate the system input for the electric Cal/day, multiply the figure times three.

Then to calculate per-person share of this Calorific total, divide by number of persons in the household (or number of students in the school, if school records are used).

Consider other ways people use energy that do not show up on their home utility bills (manufacturing costs of cars, appliances, food processing, medicines, newspapers; services of doctors, repair persons, police, and military; all construction; transportation systems to distribute manufactured goods and agricultural products; use of laundromats, hospitals, shopping malls, offices, etc.) There is a difficult-to-qualify additional daily sum of energy used per person that raises the U.S. per capita daily average to more than 220,000 Calories/day.

Compare students' calculated energy consumption with those stated on the table of Energy Consumption Per Capita in 1976 for Selected Countries. Challenge them to explain the great differences between various countries. You may want to assign each student a particular country for further investigation. Ask for reports on kinds of employment, population, size of largest city, chances for education, longevity, food situation, cultural development, transportation systems, world trade, pollution problems, and any other aspects of national life that may possibly relate to energy use.

Helpful Resources:

The Household Energy Game, $.15 cents each from Sea Grant College Program, University of Wisconsin, Madison, WI 53706

Ritsch and Castleman's Lifestyle Index '77, including charts for adding up individual energy consumption, $2.00 from Citizen's Energy Project, 1110 6th Street, NW, #300, Washington, DC 20001

Pamphlets on meter reading and typical energy requirements of appliances, free from your local utility company.

Iowa-Illinois Gas and Electric Company has a "watt-watcher" you can borrow for classroom use. The meter can monitor household appliances rated <1,000 watts (this excludes 200 volt ranges and air-conditioners). The read-out is in dollars. The meter is pre-set at current electric rates. Arrangements for this customer service can be made through Mr. Fred Maihack, Iowa City office, (319) 338-9781.

Energy Consumption Per Capita in 1976

For Selected Countries

Area	Country	Annual Per Person Consumption in kgce[a]	Equivalent[b] Calories/person/day
World:	All	2,069	39,600
Africa:	Egypt	473	9,000
	Ethiopia	27	500
	Kenya	152	2,900
	Nigeria	94	1,800
	South Africa	2,985	57,300
N. America:	Canada	9,950	190,800
	United States	11,554	221,600
	Mexico	1,227	23,600
S. America:	Argentina	1,804	34,600
	Brazil	731	14,000
	Paraguay	189	3,600
	Peru	642	12,300
Middle East:	Iran	1,490	28,600
	Israel	2,541	48,700
	Lebanon	533	10,200
	Turkey	743	14,200
Asia:	China	706	13,500
	India	218	4,200
	Japan	3,679	70,600
	Korea	1,020	19,600

Area	Country	Annual Per Person Consumption in kgce[a]	Equivalent[b] Calories/person/day
Asia (cont'd):	Napel	11	210
	Philippines	329	6,300
	Viet Nam	124	2,400
Europe:	Austria	4,013	77,000
	France	4,380	84,000
	W. Germany	5,922	113,600
	Greece	2,250	43,200
	Ireland	3,170	60,800
	Italy	3,284	63,000
	Netherlands	6,224	119,400
	Norway	5,263	101,000
	Portugal	1,050	20,100
	Spain	2,399	46,000
	Sweden	6,046	116,000
	Switzerland	3,340	64,100
	United Kingdom	5,268	101,000
	U.S.S.R.	5,259	100,900
Oceania:	Australia	6,657	127,700
	Fiji	403	7,700
	New Zealand	3,617	69,400
	Samoa	160	3,100

[a]*Data are from the 1977 Statistical Yearbook, United Nations, New York, New York. Consumption is based on apparent consumption of coal, peat, lignite, petroleum products, natural gas, and hydro- and nuclear-electricity. Wood and food are not included.*

[b]*The unit of consumption stated by the United Nations is kg coal equivalents per person. The calories/person/day figures are derived on the basis of one coal equivalent = 7,000 calories/gram, or 7,000 Calories/kg.*

Transportation: Carpooling Saves

Objective:

To develop awareness of the costs of operating a car and of the cash savings possible by carpooling.

Background:

Some people do it to save money. Some do it to conserve energy. Some enjoy the companionship during an otherwise lonely time of day. Some are in it strictly for the ride. These are the car poolers who share the daily commuting on a voluntary basis. And these are also the van poolers who pay to ride in a company-sponsored vehicle.

At least 150 major corporations around the country operate vans to transport employees to and from work (according to the Wall Street Journal, Jan. 23, 1979). Commuters say they save $1-$3 per day in travel expenses by van pooling. It reduces wear and tear on autos, and lowers the expenses of parking and fuel. Some commuters also get reduced auto insurance rates because they no longer drive to work.

Companies say that van pooling boosts employee morale, reduces absenteeism, and avoids the expense of providing individual parking places for employees. The vans usually pay for themselves, too. Fares are set on a mileage basis that takes into account the original cost of the van, less its resale value, along with fuel, insurance, taxes, and maintenance expenses over the three to four year average use. Drivers who set up their own carpools can make similar estimates in order to charge each rider a fair share.

Procedure:

Using the following figures (or up-to-date ones, as available), have students figure the costs of driving to and from school:

Car Type	Costs per mile: Depreciation (cents)	Parts & Tires (cents)	Gas & Oil (cents)	Insurance (cents)	Taxes (cents)	Total Cost (cents)
Standard	12	5	7.5	2.1	1.7	28.3
Mid-Size	11	5	5.5	2.0	1.6	25.1
Compact	9	4	4.5	2.0	1.3	20.3
Sub compact	7	4	4.0	2.0	1.0	18.0

Example:

To figure commuting cost, multiply number of miles (say 20) times cost for a mid-size car (Chevy Malibu)--

1. 20 x $.251 = $5.02

2. Add daily parking fee + $.50

3. Total daily cost $5.52

4. Multiply daily cost x number of school days per month (21) for total cost per month to drive alone ($115.92).

5. Divide this by the number of people in the carpool (say 4)--

   $115.92 ÷ 4 = $28.98, cost per passenger in car pool

6. Monthly savings, per person, is the difference in cost between driving individually and using the carpool.

   $115.92 - $28.98 = $86.94

Note that more than money is saved. Energy use is reduced, and environmental damage is also less. Parking areas do not have to be so large and the atmosphere does not have to absorb so much heat and exhaust fumes.

Now have each student compute his own commuting costs, those of a parent, or those of the "typical worker" at a nearby industry. An answer sheet is provided.

Additional Resources:

Free class copies of current gas mileage guides from U.S. Department of Energy, Fuel Economy Distribution, Office of Administrative Services, Washington, DC 20585.

Federal Highway Department Statistics from U.S. Department of Transportation, 400 Seventh Street, SW, Washington, DC 20590.

STUDENT WORKSHEET Name_____

Carpooling Cost Estimates

1. Multiply cost per mile x miles per day:

_____ x _____ = $ _____

2. Add daily parking cost + _____

Daily cost TOTAL:

3. Multiply daily cost by number of school (working) days per month x_____

Lone driver's monthly cost TOTAL:

4. Divide monthly cost of driving alone by number of people in carpool ÷_____

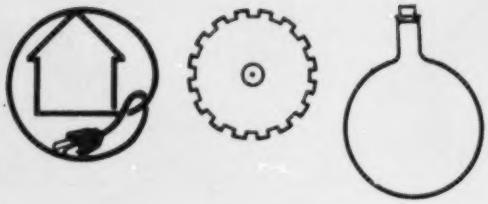
5. New cost per person by carpooling =

_____

6. Monthly carpool savings, #3 - #5

$_____ - $_____ = $_____

7. What other differences (besides personal savings) might carpooling make in your life?



Window Cover Project

Introduction:

Windows are heat exchangers. They conduct heat much faster than walls do. The resistance to heat transfer (R-value) of a single pane of glass is about 0.9. A second pane nearly doubles that value. However, compared to an exterior wall insulated to the recommended minimum of R-19, a double paned window exchanges ten times more heat.

During sunny winter days, windows that allow sunlight to enter can help heat the building for a few hours. Sunlight means warmth as well as less need for artificial light sources. But during the long periods of winter darkness, buildings lose considerable heat through windows, adding to the cost of maintaining interior warmth.

Why can't a window be a wall part of the day or part of the year (depending on its location and uses)? Thermal shutters, specially constructed shades, or sliding wall panels can be used to insulate windows from the inside of a building. Another alternative is a basic movable cover or "lid" you can make for a problem window.

Objective:

To build, decorate, and install an insulating window cover.

Materials:

One 4' x 8' sheet of 1" rigid styrofoam insulation
~ 30 lineal feet of wood lattice, 1 1/8" x 1/4"
2 plain cabinet knobs with screws or 2 screw eyes
Elmer's glue
One of the following: decorative fabric, wallpaper, foil, cork, 1/4" plywood, or latex paint
~ 30 lineal feet of weatherstripping

Tools:

Pencil and paper
Steel measuring tape or carpenter's rule
Utility knife
Hand saw
Staple gun
Mitre box (optional)

Directions:

1. Carefully measure the inside casing of the window to be fitted with an insulating cover. Record the height, the top width, and the bottom width. If the width measurements differ by greater than 1/8", you should make a paper or cardboard pattern of this non-standard opening before proceeding.

2. Subtract 1/8" from both the width and the height.

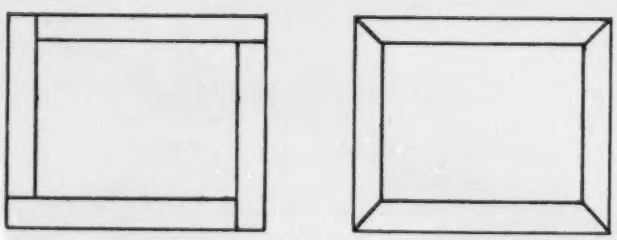
3. Using the adjusted width and height measurements, mark off in pencil the panel to be cut from the styrofoam sheet. Or, if you have made and trimmed a pattern, pin it to the styrofoam as a guide.

4. Hold the styrofoam sheet steady while you carefully cut out the panel with the utility knife. Score the styrofoam lightly in the first cut. Increase pressure on succeeding cuts until you cut all the way through.

5. Check your panel against the window for closeness of fit. Trim only if necessary because a tight fit is essential. You will find slight "give" in the material that will compensate for slight imperfections.

6. Cut the lattice strips with a hand saw to make a wooden frame for the panel. Start with exact dimensions of your cut piece and then make one of the following:

FRAME OPTIONS:



a. Box frame - Each piece is the width or length of the panel less the 1 1/8" of the lattice. Glue the frame to the panel first, then staple each joint twice.

b. Miltred frame - Each piece is the width or length of the panel. Ends are cut 45° with a mitre box. Glue frame to the panel, then staple each corner twice.

7. Consider the framed side of your panel the "outside": it will face the window. Now decorate at least the "inside" or room-facing area of your window cover. You may glue foil or cork to the room-face side. Or you may choose fabric or wallpaper to cover your panel. If so, allow a 5" margin over both length and width dimensions. Cover edges of your panel and staple the material to the wooden frame in back. You can also paint your window cover by brushing on latex paint. Or you may prefer to cover the panel with a plywood face. If so, frame both sides and then glue the plywood to the room-side face.

8. Add knobs or screw-eyes (for pulls) last. Put one on opposite ends of the room-facing side, in a convenient position for pushing on and pulling off the panel. If your window is small (about four square feet or less in area), one center knob is probably enough.

9. Apply weatherstripping around the window casing. This will help prevent infiltration.

10. Install the window cover. It should press tightly against the weatherstripping when in place. Yet it is lightweight and easy to remove whenever desired.

Extended Activity:

Answer the following questions. You may want to use the resources of your local library for ideas to incorporate in some of the responses.

1. Is window insulation important only in winter? Explain.

2. Why is window covering especially desirable at night?

3. What changes in decorative details would make this kind of window insulation more attractive to the eye?

4. Suggest another design, material, method of installation, or storage technique that would make window covers more acceptable to American consumers.

5. Inside window covers have been suggested for existing buildings in particular, where opportunities for major structural changes are limited. They are an add-on or retrofit strategy. Find out about other retrofits and suggest one that would make your home or school more comfortable while using less energy than before.

6. If you were building a new home or school this year, all done to your specifications, what features would you include in order to avoid excessive heat transfer by windows?

Teacher's Guide to Window Cover Project

Time Required:

To complete the basic construction project at least two class periods (45-50 min. each) are needed. Plan ahead. Either have student pre-measure a window at home, or you identify windows within the school building that are accessible and would benefit from insulation.

CAUTION: Note that styrofoam should not be used near flame or in areas that are likely to get unusually warm (greater than 160° F).

Basic Costs:

Exact cost is difficult to figure, but it's at least $1 per square foot (at 1980 prices) for the basic, undecorated, single panel. In June 1980, a 1" thick, Dow extra-strength styrofoam panel cost $11.15 in Davenport, IA; the lattice cost $.11 per lineal foot; sturdy screw eyes were $.07 each while conventional pulls were greater than $1; self-adhesive rolled foam weatherstripping tape cost $.05 to $.15 per lineal foot, price depending on width of material.

Whether one or eight window covers can be cut out of each sheet of styrofoam depends on the size of the windows. Whether all 32 square feet of material per sheet is used is problematic also; usually there will be plenty of scraps.

Insulating Value

The R-value or resistance to heat transfer will depend on the R-value of the rigid insulation used plus the R-value of the decorating material.

For one example, Dow extra-strength styrofoam in 1" thick sheets has an R-value of 5.4 at 40°F. If your target window has a deep enough frame to accommodate a 2 1/4" window cover, you can double the effectiveness of the basic insulation. Cut a duplicate panel and glue it to the outside-frame of the original cover. You now have a styrofoam sandwich with a wood and air filling. Even without any additional insulation from material added to decorate the face, this thicker cover would have an R-value of 11.

Design Alternatives for Rigid Panels:

Magnets along the window casing attracting opposing magnets inserted in the edges of the styrofoam are a feature suggested in popular magazines.

Wooden channels on the ledge in front of windows would permit sliding panels.

Door tracks on a ceiling could support wood-encased panels for whole-wall coverage in some situations.

Carefully hinged and weatherstripped folding screens might be appropriate to cover large windows; they'd be less awkward to store than a bulky, totally rigid cover.

Side-hinges only or folding-shutter hardware for hanging insulating panels permanently on the wall solve a storage problem, but this alternative is not feasible for all types of windows and it does increase costs.

Energy Use and Decision Making

Objective:

This multidisciplinary activity provides students an opportunity to simulate the fact finding and decision-making process exercised in making choices about energy use.

Directions:

Let students select one or more of the Energy Use Situations prepared for this activity. Situations should be considered as though they are occurring in the local community. Responses should be defendable. Students may need to do some library research or to contact local professionals for more information so that they have several reasons for their choices and are aware of other possible perspectives as well. Require students to write reports of choices made (maybe in the form of an editorial for the school paper or a "letter to the editor" of the local newspaper), stage classroom debates, or conduct a consensus-seeking discussion.

Whichever technique you use, also consider exploring choices further via a Futures Wheel (in TRENDS AND CONSEQUENCES), as described elsewhere in this publication.

Energy Use Situations:

1. Assume that you are a local celebrity whom people like to imitate. If your position makes it possible to influence energy use habits in your community, then:

    a. Would you limit energy use? In what ways? Why?
    b. What are the most important human factors you would have to consider?
    c. What provisions would you make for the elderly on small pensions? the unemployed? the sick?
    d. What special consideration (if any) would you give to jails, schools, office buildings, hospitals, indoor sports facilities, theaters, restaurants?
    e. How would you (or would you) make exceptions for emergency needs without appearing inconsistent?
    f. Would you personally adopt an unpopular measure (example: no air conditioning for your home and car) at the risk of losing your popularity and influence?

Acknowledgement: This activity, adapted from one included in Ideas and Activities for Teaching Energy Conservation: Grades 7-12, 1977, $2, is available from the Tennessee Energy Authority, 226 Capitol Blvd., Bldg. Suite 707, Nashville, TN 37219.

2. Imagine that you are a public official with power to legislate energy use.

   a. How would you reach decisions? Would you listen to certain groups of citizens more than to others? Or would you postpone action indefinitely in hopes that need for legislation would disappear in time?
   b. Assume that you do legislate specific energy-related actions. How would you put them into effect?
   c. What factors could change the need for, or effectiveness of, changes by law?
   d. Would you ever approve and put into effect unpopular laws? Give reason and at least one example for your answer.

3. Imagine that you are the recreational planner for your community. Gasoline shortages are keeping your neighbors closer to home than usual and you are pressured to find more low-energy outlets for their leisure hours.

   a. Would you schedule athletic events only during daylight hours? What would be the advantages and disadvantages of this policy?
   b. What areas in your town are near major concentrations of people and could be used for parks?
   c. Would bicycle and jogging trails be popular in your area? If so, suggest a route for one.
   d. Some people would like to exercise during their lunch hour. What provisions for recreation can you make at or near major workplaces?
   e. Where are the most energy-efficient places in town to hold social gatherings, bazaars, fairs, tournament games, square dances, play practices, etc.?
   f. What recreational activities available in your community require the least use of non-renewable fuels? The least use of human energy? Would these factors dictate your decision on which ones to encourage with use of your limited time and money?

4. Assume that <u>you</u> are going to buy the family car.

   a. What type of car would you buy? Why?
   b. Would you buy a used auto? Why or why not?
   c. What options would be <u>necessary</u> on this car?
   d. Calculate what the life-cycle cost in dollars of the car of your choice is likely to be.
   e. Make a list of advantages and a list of costs of using an auto that are not usually measured in dollars.

5. Assume that you have responsibility for choosing a local citizen to receive a $1,000 conservation award and gold medal from the President of the U.S.

   a. What kind of lifestyle and behavior would you look for?
   b. Do you think the person you're seeking is most likely to be young, middle aged, or old? living on very limited income, having an average salary, or living comfortably on high income? knowing much or little about energy problems?
   c. What energy conserving features would you look for on the interior of candidates' living spaces?

d. If the persons being considered own homes, what features would you hope to find on the exterior of their houses?
e. If candidates own cars, what kinds and what uses would you expect?
f. Design an appropriate medal that the President can use for this award.
g. Would you put any limitations on how the $1,000 is spent, in the interest of saving energy?

6. Imagine that you are a creative director of an advertising agency. The local utility companies have hired you to develop an advertising campaign, using any media you choose, to encourage energy conservation in Iowa.

   a. Who would be some of your target audiences? Would you use different approaches for each?
   b. Enlist classmates to be your photographers, artists, creative writers, programmers, and salespeople. Decide whether to write songs or slogans for radio; to prepare graphics for newspapers and billboards; to prepare brief action skits for television; to design T-shirts and campaign buttons for mass distribution; to design bumper stickers or to assemble a photo essay for a magazine, etc. Then <u>do it</u>.
   c. Find out what community resources (information, publication space, manpower, materials) may be available to you for this project. Decide which ones you'll use, or which are most likely to give your advertising a wide audience.

7. If you were mayor of your city and you were starting a citizens' advisory committee to make suggestions for energy conservation . . .

   a. What kinds of persons (by education, occupation, political philosophy, age, experiences, wealth) would you choose? How many would you want? Explain.
   b. What problems would you assign this committee?
   c. What responsibilities and decision-making power would the committee have?
   d. Who would follow-through on committee recommendations?

8. Assuming that you want to live in the most uncomplicated and least energy-expensive way in the future:

   a. Where in the world would you live? Why? Where would you <u>not</u> live and why?
   b. How would you support yourself?
   c. In what ways would you use less energy than now?
   d. What kind of house would you buy or build?

9. You have just been hired as energy manager for a large school system. Imagine that you can earn a salary bonus by reducing the winter heat bills on the several buildings maintained by the board of education.

   a. How would you encourage students and teachers to save energy?
   b. What maintenance procedures would you require?
   c. What new devices or materials would you hope to install?

10. Assume you are on the planning commission and must approve or reject a permit for strip mining at the edge of town.

    a. What economic factors would you consider?
    b. What social factors should be weighed?
    c. What environmental factors would be critical in your area?
    d. What other kinds of information would you want before making your decision?

11. As superintendent of the local schools, you are asked to consider changing the school calendar. In order to reduce skyrocketing fuel costs, the Taxpayers' Union has recommended that the major vacation starting in mid-December be extended through January and February. Extra school days in June and August, when building heat is not required, would be substituted.

    a. Would you save much money under this scheme? How low can you leave thermostats if children are not present?
    b. What would the effects of this new schedule be on local businesses? on parents? on student learning?
    c. How would your decision affect busing and other forms of student transportation?
    d. What activities would students likely substitute for school during a long winter vacation?
    e. What other social and economic effects might your agreement with the Taxpayers' Union have?

12. Imagine that you live in a house you've owned for years, near people you know well and like. Now you've just been offered an attractive, interesting job, but its location is fifty miles away. "Move or commute?" is the decision you must make.

    a. What choice would be most economical in dollars; in time; in energy; in personal and social stress?
    b. Before you answer 12a., what kinds of information would you need? Whom would you consult?
    c. What events and costs are impossible to anticipate (if any)?
    d. If you do move, what energy-saving steps would you take while relocating?
    e. If you do not move, what energy conservation options do you have?

Teacher's Guide to
Energy Use and Decision Making

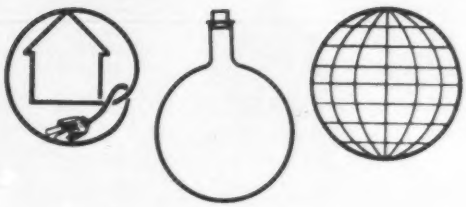
Some explanation may be due for situation 4d.

Life-cycle costing is an attempt to estimate expense of buying, maintaining, and retiring an article over the time of its useful life. Such calculations allow comparison of articles with similar initial costs, but differences in service life. For example, a wedding dress costing $200, worn only once has a life-cycle cost of $200 per day (plus any cleaning and storage costs, minus any resale value). A business suit costing $200, worn 30 times a year for five years, will need regular dry cleaning . . . say $100 worth over the five years. So the suit's life-cycle cost is $\frac{\$200 + \$100}{30 \times 5 \text{ wearings}}$ = $2.00 per day.

Disposal cost, if any, should be added to the total cost. Or salvage value, if any, should be subtracted to reduce this figure.

Estimating the life-cycle cost of a car is done in a similar manner. cost of ownership is more than purchase price minus resale or salvage value. One must add insurance costs; license and registration fees; fuel required; maintenance and repair costs; interest expenses if a loan was required; washing, waxing, parking, and storage expenses. Then compute:

$$\frac{\text{Costs incurred + Costs anticipated during useful life}}{\text{Time of useful life}} = \text{Life-cycle cost}$$



Trends and Consequences:
The Futures Wheel

Background:

The energy transition is making us aware that energy is a potent social and economic force. Some of the effects of shortages of fuel, such as inflation and unemployment, hint of lifestyles in the future that may be different from those to which we are accustomed. We want to know not only about the choices available to us, but also what the consequences of various alternatives may mean to us, to our society, and to the world community in the future.

Activity:

A futures wheel is a tool to help students examine possibilities and consequences of following trends or using innovations. It is a graphic way to emphasize complex interrelationships.

Materials:

Magic markers and newsprint or butcher paper; or
large chalkboard and chalk

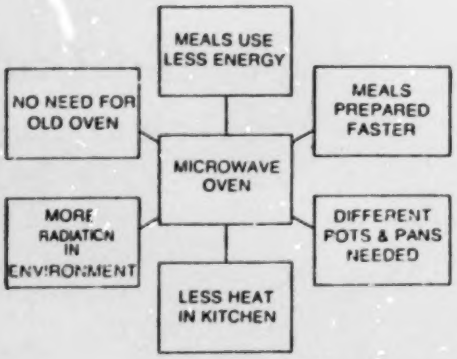
Directions:

Near the center of the paper or the chalkboard, write the name of an energy innovation or trend (a gasoline tax increase of $.50/gallon; farmers refuse construction of high voltage lines over their property; sales of wood burning stoves are up 500%; solar heating systems are mass-produced; thermostats in all schools are kept at 65°; only Australia has uranium left; fusion succeeds; electric cars are widely used; sun rights of individual property owners are protected by law; etc.).

Draw a circle or a box around the item chosen. Then ask the class, "What are the probable consequences of this innovation or trend?"

Write each of the effects outside and around the circled energy innovation or trend and draw circles or boxes around each of them. Draw lines connecting them to the original. An example for "microwave oven" is shown. The initial reactions are called first order consequences. They are indicated by the single lines connecting the energy innovation with its possible consequences.

Diagrams from Joel Barker,
Director, Future Studies Dept.
Science Museum of Minnesota,
St. Paul, Minnesota 55101
Used with permission.



Now ask the question--"What are the possible effects of this consequence?" for each of the first order consequences. Draw in and connect each secondary effect proposed by students with two lines between it and the first order to which it relates. Continue this process for about four orders of consequences, using three lines for connecting third order ones and four lines for the fourth order.

It's usually wise to limit the futures wheel to no more than four orders in classroom use. Not only do possibilities get more remote, but also there are visual, spatial, and conceptual limits to be respected. (However, some students may be intrigued enough to enjoy the challenge of a futures wheel assignment to be done outside of class with a less limited time constraint.)

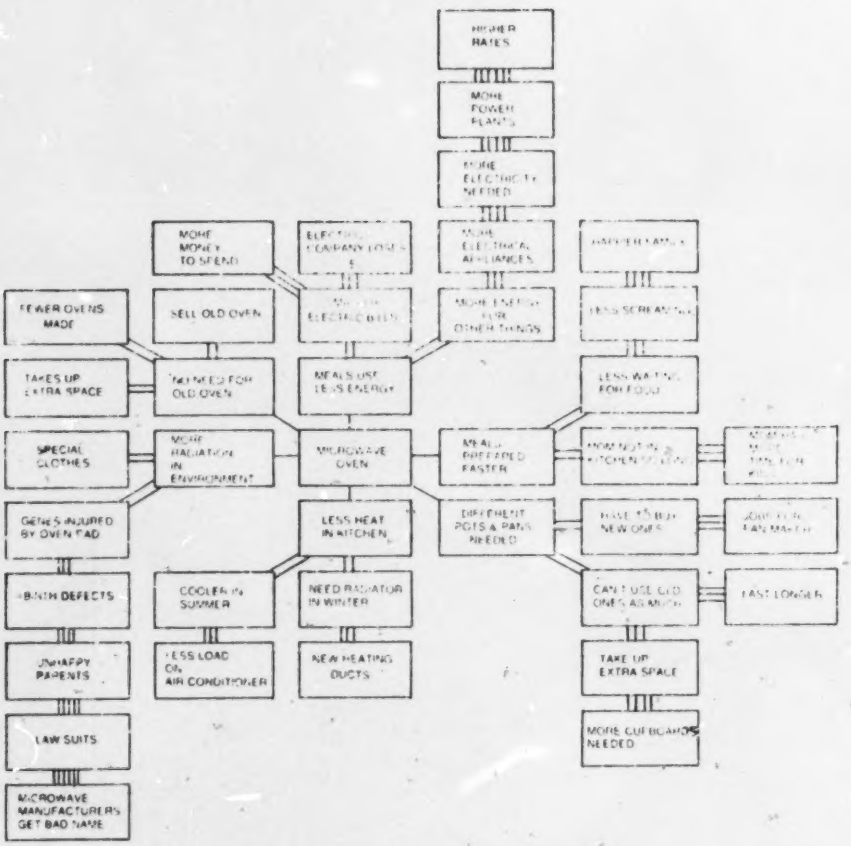
A futures wheel developed for the microwave oven is included for an example of a way to show multiple consequences. The number of connecting lines between boxes indicates the order of each effect.

Remember that the assumptions learners make are not right or wrong and do not have to be highly probable. They represent possibilities only and should be recognized as such.

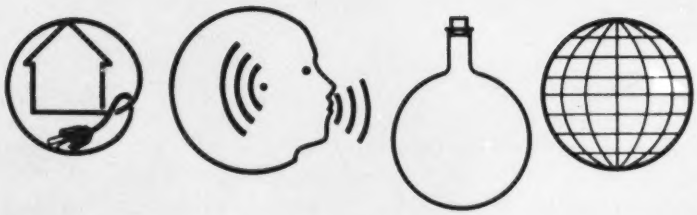
Now that you have shown students how to draw a futures wheel, ask each to make one individually or with a small group (4 to 6 are recommended for brainstorming), using a different energy-related innovation or energy trend. On completion, hang the wheels on the walls and have students share them with the class.

As a follow-up activity, have students categorize the nature of the various consequences. Are they social, economic, technological, environmental, or related to world politics for example. (First let students suggest all the

categories they can recognize. Then combine or elaborate on them as necessary.) Then tally the responses by category. What kinds of effects were easiest (most often mentioned) to foresee?



Reference: J. A. Barker, "Futures Study in Curriculum Planning," pp. 56-61 in The Role of Future Studies in Public Education. Misc. Publ. of the Science Museum of Minnesota, No. 4. St. Paul, MN, 55101.



Ye Olde Times

FIRE IS BASIC,
GREEK ASSERTS

1

Ephesus, Asia Minor, c. 500 B.C.

Ideas of the reclusive philosopher Heraclitus are exciting the educated citizens of Ephesus. Fire made the universe, not the gods, Heraclitus claims. "Everything originates and ends in a fire that kindles itself and goes on refueling itself until it puts itself out. And matter is like fire in that it always moves, always changes somewhat," states this student of nature.

King Darius of Persia has tried to honor Heraclitus for his provocative thinking, but the Greek sage tactlessly refuses all honors and society as well. He was recently seen gathering roots and berries outside of town, and friends report that he spends months at a time alone in the countryside. Heraclitus's refusal to cultivate admirers and followers and to lead a more civilized life may retard the spread of his natural science. Ephesians marvel, nevertheless, that this cold man has such hot ideas.

"If sunbeams were weapons of
war we would have had solar
energy centuries ago."
--Sir George Porter

SECRET WEAPON
BURNS INVADERS

2

Syracuse, Sicily c. 214 B.C.

Under the direction of the respected mathematician and inventor, Archimedes, the citizens of Syracuse succeeded in turning back a fleet of Roman war galleys. Wooden missiles and masses of stone were hurled at the invaders with such force that they had little opportunity to use their own war engines against the city's walls before being terrified by an unnatural fire.

Archimedes' mechanical devices for defending his birthplace are well known for their ingenuity and usefulness in both long- and short-range combat. Today, though, he demonstrated an awesome new power to set fire to distant sailing ships without using projectiles.

One of the few surviving eyewitnesses of the Roman rout claims that he saw a blinding light appear on the steep Sicilian hillside a half-mile ahead of him just one second before the sails on a neighboring galley burst into flame. Though this Roman soldier was standing on deck with the sun behind him, he then saw another brilliant flash come from the same area of the Greek stronghold. Before he could regain his vision, he smelled the charred remains of burnt cloth and felt the heat of flames licking the masts of his own ship. How he escaped, he declines to say, for fear of being sent back for cremation by that wizard of Syracuse, Archimedes.

Citizens within the besieged city report that Archimedes borrowed every available mirror that wealth and vanity made common in this prosperous town. Then he stationed dozens of stalwart men on a steep hillside facing the harbor. Each held and moved a metallic mirror as Archimedes directed, focusing reflected sunlight on the sail of a Roman galley. The Syracuseans were surprised and delighted that this novel strategy set fire to a couple of the advancing ships. The effect seemed to demoralize the other Roman crews, and the enemy retreated back to the mainland.

This battle will be long remembered, whatever the outcome of the ongoing Punic Wars.

ACADEMY HONORS YOUTH
FOR LIGHTING RESEARCH

3

Paris, France, 1766.

Although he did not win the coveted 2,000 livres offered for an essay on means of lighting city streets, young Antoine Lavoisier has earned a unique honor. A special gold medal struck "by order of the King" was presented to him in the Louvre by the President of the Academy of Science.

The unprecedented distinction was given to the 23-year-old author for his exposition of the theoretical aspects of the lighting problem. Lavoisier had studied every kind of lamp available. He considered candle-powered lights as well as oil burners and calculated relative efficiencies of different fuels, of variously styled wicks, of elliptical and hyperbolic reflectors, and of assorted light standards. The economics of the project for street illumination were also explored mathematically. The versatile fellow estimated costs of installation and maintenance and made suggestions for financing the civic improvement.

Seldom have intellectual energies been so masterfully displayed over a problem of public concern. Fellow citizens are pleased that Lavoisier's merit was officially recognized.

FLAMELESS METHOD
MELTS STEEL BARS

4

Paris, France, 1772.

Using only sunlight, Antoine Lavoisier melted steel today in his outdoor funace. The renowned French chemist has built an original contraption on a flat, wheeled platform that can be pushed to track the sun horizontally. The critical components mounted on the platform include a large parabolic mirror and two huge lenses made hollow, like flattened wine bottles. These lenses were borrowed from the Academy of Sciences and were modified slightly by Monsieur Lavoisier. He filled each lens cavity with his favorite beverage, spirits well known for their capacity to warm the consumer.

Supporting rods for the lens-holder can be handcranked to raise and lower the lens system vertically. The parabolic mirror bounces and concentrates the lens-gathered light into one point where the steel sample (or other material) can be strategically placed.

Today's demonstration was not so dramatic as was Lavoisier's previous use of sunshine to shrink the size of a diamond. However, the potential usefulness of a solar device to blacksmiths, jewelers, glassblowers, brick makers, and other craftsman became apparent today. This puts the new arrangement of burning lenses in a more practical light and may justify its further development.

Lavoisier has already announced plans to experiment further, perhaps using wines of varying color and clarity--or even less popular fluids--in subsequent models. Thus a range of "heat peaks" may be made available for specific jobs. Now if the distinguished chemist can find a reliably cloudless site for his sunlight concentrators, he may provide a focal point for some bright new industries.

DYNAMO INVENTION
GENERATES ENERGY

5

London, October 28, 1831.

A laboratory assistant at the Royal Institution, Michael Faraday has invented a "dynamo" for converting mechanical force into electrical energy.

While continuing experiments begun by Monsieur Ampere, Mr. Faraday discovered that moving a magnet through a coil of copper wire caused a current to flow through the wire. This "electromagnetic induction" is the basis of his new dynamo which may lead to generation of low-cost electricity. It is also believed that it may be the basis for a whole new generation of machines to make men's lives easier.

369208

Though Mr. Faraday's invention is as yet only a novelty, insiders at the Palace predict that it will earn him honors but not a penny in royalties. One skeptical politician already has asked the experimenter what use his little electrical toy may have. Faraday replied, "Some day you will be able to tax it."

FIRST POWER STATION
SERVES NEW YORK

6

New York, New York, March 12, 1882.

The first establishment for electrical energy supply was opened as the "Pearl Street Edison Station" in New York City. Coming only three years after T. A. Edison's invention of a sootless incandescent lamp, this power station will supply enough electricity to light up a small group of adjacent buildings.

Experts on electrical transmission anticipate the possibility of networks of power stations and long-distance transmission of electricity in the decades ahead. However, much more research and development of high-voltage systems will be necessary before these goals become realizable.

COAL TAR MAKES BASE
FOR GERMAN INDUSTRY

7

Germany, 1890.

The booming new chemical industry has made Germany the world leader in manufacture of dyes and pigments, fertilizers, insecticides, medicines, and synthetic drugs. All of these products are derived from coal tar, the raw material for an ever-increasing variety of products and chemicals that meet ready acceptance in world markets.

Much of Germany's current prosperity is based on the work of one man, August von Hofmann. His research into the organic components of coal gas and coal tar led to discovery of several compounds--anilines being the most notable--that are the feeder stocks for a whole series of commercially valuable chemicals.

In former years Herr von Hofmann worked in London, England, as director of the Royal College of Chemistry. After the loss of both his patron (Prince Albert) and financial support for the college, von Hofmann returned to his fatherland. England's loss was our gain. Von Hofmann's unprecedented contributions to coal tar chemistry and its applications in practical life have brought international recognition to himself and to Germany.

PEDAL POWER
CRAZE GROWS

8

New York, New York 1898.

Pneumatic tires have now made bicycling a comfortable as well as a practical means of transportation, and it is fast becoming America's favorite pastime. The geared-up transmission of the "safety" bicycle is also a factor in the new found popularity of this vehicle.

The older generation may remember previous models of bicycles that only the daring could endure. The "ordinary" bicycle manufactured since 1872 had a front wheel nearly ten times as large as the rear one and favored the tallest riders. A "geared ordinary" was an improvement on the basic model but still required a skillful rider to maneuver it.

The first crank-driven bicycle was initially manufactured even earlier, in 1865. Called a velocipede, its wooden wheels were nearly equal in size, covered with thick iron tires, and attached to a cast iron frame. If its excessive weight didn't discourage the rider, then its terrifying vibration would. Also called "boneshaker," the velocipede never attained widespread popularity. It was, however, a more efficient device than its prototypes, the first bicycles. These were walk-along scooters one could really "ride" only downhill.

Now after 88 years of progressively better designs, bicycles are taking their place in city transportation plans. Bicycle racks are being installed at commuter train stations, shopping areas, and parks for the convenience of those who prefer freewheeling to walking.

The Sun Press

A STIRRING SOURCE
OF FARM HOT WATER

10

N. Y. State, March 1978.

Researchers at Cornell University, New York, are using a wind turbine to agitate water in a 30 gallon drum. As James Joule and Count Rumford both declared more than 100 years ago, heat is a product of motion. The system testing this premise keeps water agitated continuously in an insulated, air tight container at the base of a horizontal axis turbine. In 30 hours at a wind speed of 10 mph, the water temperature rises from 50° to 150° F. During the winter when wind speed sometimes doubles, production increases by a factor of 8, enough to heat 240 gallons of water.

The Cornell research team hopes to demonstrate that wind power can ease agricultural energy consumption. Dairy farms in particular use much hot water to clean milk handling equipment. However, the wind system design will easily adapt to domestic hot water and space heating uses, its developers claim. Professor W. W. Gunkel predicts that turbine manufacturers will be able to market a complete hot water package within 2 to 4 years. Hopefully it will be economical in windy areas.

A notable advantage of the Cornell system is that the water brakes the speed of the turbines in high winds, eliminating the need for complicated braking devices. Producing heat by direct agitation of the water also bypasses the need for any expensive conversion units to transfer wind speed into electrical energy.

SELF-LIQUIDATING
WATER HEATERS

11

Lakeland, Florida, 1978.

Loans on installation of solar water heaters are being encouraged by the Florida Savings and Loan office in Lakeland. Consumer repayments are set at $25 a month regardless of the total amount loaned. This monthly installment approximates the expected utility bill reduction. Therefore, borrowers' budgets aren't likely to be affected by the loans.

VOICES ON
THE WIND

12

Plymouth, N.H., January 1979.

Up in breezy New Hampshire, students at Plymouth State College have harnessed the wind to run the campus radio station.

The roof of the science building supports a windmill erected last year to demonstrate its possibility as a generator of electricity. At first the windmill lit up a sign declaring "Wind Power." but now the windmill is used to power the college's 10-watt radio station.

On an average day, ordinary wind runs the station for 3 to 4 hours. Stronger winds in the 24 mph range produce all the power needed for a broadcast day. The campus radio staff uses a jingle to advertise times when "This hour is 100% wind-propelled."

JAPAN LIGHTS UP
ON NUCLEAR POWER

13

Tokyo, Japan, January 1979

Ten percent of this island nation's electricity is provided by nuclear power plants with a peak capacity of 9.6 million kilowatts. Among the world's nations, only the U.S. has more nuclear power capacity.

Japan is constructing more nuclear generating facilities, aiming to provide nearly 22% of her electrical needs within the next 10 years. Otherwise she is totally dependent on imported fossil fuels, especially oil.

A FUELISH REVERSAL

14

Newcastle, England, 1977.

"Carrying coals to Newcastle" has long described the futile effort of taking some commodity to an area that already has a surplus of it. Newcastle started selling off its coal in the 13th century, and that fuel became its major export from the 17th century to the present.

The end of an era came this year when coal industry officials admitted that reserves are so low that Newcastle cannot meet her own present needs for coal, much less export any. Hopefully North Sea oil will come into the pipelines soon enough to keep this industrial center going.

Meanwhile, "carrying coals to Newcastle" would seem to be a highly appropriate response to her needs.

PENNSYLVANIA LEADS
IN WEATHERPROOFING **15**

Harrisburg, PA, December 1978

If there was a national contest for energy-wise home improvement, the state of Pennsylvania would probably win it. The Department of Community Affairs has already helped insulate and winter-proof over 35,000 homes. It is continuing this program at a rate of 1,500 houses a month.

Over 800 people were trained in skills ranging from basic construction to energy auditing. This job corps has been a basic ingredient in the success of the energy-saving project.

State officials estimate that the first 24,000 households weatherproofed had saved the equivalent of 114,285 barrels of oil by January 1978. This was a cost reduction of $2.4 million or $100 per household for the first year.

MODEST TREASURES
CONVERT TO ENERGY **16**

Here and There, 1979.

Calorific Recovery Anaerobic Process, Inc. (Oklahoma) uses leftover cattle feed and other wastes to produce methane gas. Bacterial action decomposes the material in large tanks or "digesters."

Sugar cane wastes are burned to generate electrical power in Hawaii, yielding about 40% of the island's electricity.

Train carloads of coffee grounds, a byproduct of instant coffee production, are now mixed with conventional fuels to fire the boilers at an American food-processing company's coffee plant.

Garbage is used as a partial substitute for oil in the power-generating plants of a half-dozen European cities.

A FAMILIAR RING? **17**

"There is one obstacle to further advance . . . . The increasing price of fuels necessary to work machinery. Coal and oil are going up and are strictly limited in quantity . . . We are spendthrifts in the matter of fuel and are using our capital for our running expenses.

"In relation to coal and oil, the world's annual consumption has become so enormous that we are now actually within measurable distance of the end of the supply. What shall we do when we have no more coal or oil?

"Alcohol makes a beautifully clean and efficient fuel . . . we can make alcohol from sawdust, the waste product of our mills . . . from cornstalks and in fact from almost any vegetable matter capable of fermentation. Our growing crops and even weeds can be used. The waste products of our farms are available for this purpose, and even the garbage from our cities."

--Alexander Graham Bell, before the District of Columbia's McKinley Manual Training School graduation, February 1, 1917.

OIL DOES GROW ON TREES (SOMETIMES) **18**

Manila, Philippine Islands and Berkeley, CA, 1979.

Can oil grow on trees--or even shrubs? The answer is yes.

Filipino scientists have shown that coconut oil can substitute for diesel fuel. It burns cleanly and causes less engine corrosion than conventional fuel. According to the Philippine Coconut Authority, no engine modifications were necessry.

Commercial production of coco diesel is not planned at this time, however, because it is more expensive than imported fuel.

Another renewable source of liquid fuel may be the "gopher plant" that lives in the California desert. Its milky sap is rich in hydrocarbon similar to those in gasoline.

University of California biochemist Melvin Calvin estimates that an acre of gopher plants may produce 10 to 50 barrels of oil each year. Dr. Calvin calculates that an area the size of the state of Arizona could supply enough hydrocarbons to meet current U.S. needs for gasoline.

Plants would be cut off at ground level and run through a crushing machine to extract the sap. Sap would then be processed in an ordinary oil refinery. Meanwhile, new shoots would sprout from the cut stumps to produce a whole new field of oil-bearing shrubs.

Believing in the power of gopher plants, Dr. Calvin has already begun raising them on his ranch in northern California. He has become the West's first gasoline bush farmer.

BICYCLE COMMUTING:
A WHEEL DEAL

19

U.S., 1979.

While many commuters are simply piling more people into their cars, others have taken to their bicycles. Though heavy traffic, poor road conditions, and lack of secure parking facilities have discouraged many would-be bicycle commuters, programs across the country are providing model solutions to these problems.

For those in the Washington, DC area who are perhaps reluctant to try bicycle commuting, the Washington Area Bicyclist Association is making it easier. Their innovative Pedal Pool Program provides escorts for first-time bicycle commuters and is collecting routes from seasoned commuters to publish in a Washington area bicycle user's map. The program also includes efforts to eliminate trouble spots identified by commuters, from potholes to poor traffic patterns which make bicycle travel dangerous.

In San Diego and Seattle, cyclists can ease their commutes by going part of the way by bus, now that some city buses are equipped with bicycle racks. San Diego's program has been operating since 1976 and racks on 16 buses on three routes assist 13,000 cyclists a year. One popular route runs between the beaches, where parking is at a premium, to the sprawling university campus, where a bicycle is almost a necessity for getting around. Route schedules are not affected by cyclists racking their bikes--it only takes about 10 seconds to lock a bike in place.

California's State Transportation Authority has set up a shuttle bus and trailer system to shuttle cyclists across the San Francisco-Oakland bridge for a small fee. The Bay Area Rapid Transit System also permits bicycles on its trains during off-peak hours at no extra charge.

As a solution to one major commuter cycling problem, finding a secure place to park a bicycle, subway stations in Washington, DC now have bicycle lockers which they rent for $25 for three months to cyclists who want to split their commute between pedal power and public transportation.

Bicyclists themselves have been working to make their contributions to energy conservation more readily available. Local bicycle clubs have worked to develop

bike paths, and greater safety on commuting routes. Members also encourage employers to provide safe parking and changing facilities. A national organization that works to improve road conditions and other concerns of cyclists provides information on ways and means to do so.*

League of American Wheelmen, 19 S. Bothwell, Palatine, IL 60067. (312) 991-1200.

Star Gazette

"All the future that's fit to print"

FROM HUMAN FOOD
TO MACHINE FUEL

20

Brasilia, Brazil, 1995.

The energy of sugar cane and tapioca (manioc) has long been a staple in the diet of Brazilian citizens. But these plants now fuel machinery as well.

Fermentation of sugar produces alcohol that is being concentrated to 95% purity by alcohol-distilling plants. The resultant ethanol provides locally-produced fuel for industrial combustion engines. This large-scale, government assisted production of alcohol has greatly reduced Brazilian oil imports.

Success of the farm-grown energy program was forecast as early as 1978 when 500 telephone-repair service cars were operated on 190-proof grain alcohol distilled from sugar cane. The superior performance of this fleet of Volkswagens plus the lack of polluting emissions from these cars appealed to most citizens. Many car owners converted their car engines to use this clean-burning ethyl alcohol. This popular response spurred automakers to market a modified interal combustion engine and to meet the demand for cars and farm machiery that burn renewable, home grown fuel.

WILL COAL BECOME
NEXT POWER BASE?

21

Cambridge, England, 4000 A.D.

Dr. O. R. Frisch, noted scientist and writer, has been considering the feasibility of coal as a source of electrical power generation ever since this mineral was discovered in several archeologicge digs on the Western Atlantic Continental Mass. His report to our readers follows:

COAL:
possibilities
and
problems

THE FRISCH REPORT

The recent discovery of coal (black, fossilized plant remains) in a number of places offers an interesting alternative to the production of power from fission. Some of the places where coal has been found show indeed signs of previous exploitation by prehistoric men, who, however, probably used it for jewels and to blacken their faces at religious ceremonies.

The power potentials depend on the fact that coal can be readily oxidized, with the production of a high temperature and an energy of about 0.0000001 megawatt days per gram. That is, of course, very little, but large amounts of coal (perhaps millions of tons) appear to be available.

The chief advantage is that the critical amount is very much smaller for coal than for any fissile material. Fission plants become, as is well known, uneconomical below 50 megawatts, and a coal driven plant may be competitive for small communities (such as small islands) with small power requirements.

DESIGN OF A COAL REACTOR

The main problem is to achieve free, yet controlled, access of oxygen to the fuel elements. The kinetics of the coal-oxygen reaction are much more complicated than fission kinetics, and not yet completely understood. A differential equation which approximates the behavior of the reaction has been set up, but its solution is possible only in the simplest cases.

It is therefore proposed to make the reaction vessel in the form of a cylinder, with perforated walls to allow the combustion gases to escape. A concentric inner cylinder, also perforated, serves to introduce the oxygen while the fuel elements are placed between the two cylinders. The necessary presence of end plates poses a difficult but not insoluble mathematical problem.

FUEL ELEMENTS

It is likely that these will be easier to manufacture than in the case of fission reactors. Canning is unnecessary and indeed undesirable since it would make it impossible for the oxygen to gain access to the fuel. Various lattices have been calculated and it appears that the simplest of all--a close packing of equal spheres--is likely to be satisfactory. Computations are in progress to determine the optimum size of the spheres and the required tolerances. Coal is soft and easy to machine, so the manufacture of the spheres should present no major problem.

OXYDANT

Pure oxygen is, of course, ideal but costly; it is therefore proposed to use air in the first place. However, it must be remembered that air contains 78 percent nitrogen. If even a fraction of that combined with the carbon of the coal to form the highly toxic gas cyanogen, this would constitute a grave health hazard (see below).

OPERATION AND CONTROL

To start the reaction, one requires a fairly high temperature of about 988°C. This is most conveniently achieved by passing an electrical current between the inner and outer cylinder (the end plates being made of insulating ceramic). A current of several thousand amperes is needed, at some 30 volts, and the required large storage battery will add substatially to the cost of the installation.

There is the possibility of starting the reaction by some auxiliary self-starting reaction, such as that between phosphine and hydrogen peroxide; that is being looked into. Once the reaction is started, its rate can be controlled by adjusting the rate at which oxygen is admitted. This is almost as simple as the use of control rods in a conventional fission reactor.

CORROSION

The walls of the reactor must withstand a temperature of well over 1,000°C in the presence of oxygen, nitrogen, carbon monoxide and dioxide as well as small amounts of sulphur dioxide and other impurities, some still unknown. Few metals and ceramics can withstand such gruelling conditions. Niobium with a thin lining of nickel might be an attractive possibility, but probably solid nickel will have to be used. For the ceramic, fused thoria appears to be the best bet.

HEALTH HAZARDS

The main health hazard is attached to the gaseous waste products. They contain not only carbon monoxide and sulphur dioxide (both highly toxic) but also a number of carcinogenic compounds such as phenanthrene and others. To discharge these into the air is impossible; it would cause the tolerance level to be exceeded for several miles around the reactor.

It is therefore necessary to collect the gaseous waste in suitable containers, pending chemical detoxification. Alternatively, the waste might be mixed with hydrogen and filled into large balloons which are subsequently released.

The solid waste products will have to be removed at frequent intervals (perhaps as often as daily), but the health hazards involved in that operation can easily be minimized by the use of conventional remote-handling equipment. The waste could then be taken out to sea and dumped.

There is a possibility--though it may seem remote--that the oxygen supply may get out of control. This would lead to melting of the entire reactor and the liberation of vast amounts of toxic gases. Here is a grave argument against the use of coal in favor of fission reactors which have proved their complete safety over a period of several thousand years. It will probably take decades before a control system of sufficient reliability can be evolved to allay the fears of those to whom the safety of our people is entrusted.

PAGE 383 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

Teacher's Guide to Ye Olde Times.
The Sun Press and Star Gazette

Note the past, present, and future orientation of the various stories. Some suggest the nucleus of a "history of science" in popular form. Others are comments on contemporary responses to energy transitions and problems. Still others project a future when energy management is assumed to be different from that of the 1980's.

You may use these articles in a number of ways. Some suggestions are:

Discussion starters.

Supplementary reading.

Examples of reports students may write for their class, school newspaper or a special energy newsletter.

Focus for critical examination. Some questions to ask are:

1. What is the value-orientation of the person or nation mentioned in the article?

2. What is the point of view of the writer of the article?

3. How did or how will the person, idea, or technology described affect mankind?

4. How do you rate the importance of the person, idea, or technology described in this article? Explain.

Introduction to the history of science. Have students write either journalistic interviews, reports, or case studies on other energy-minded scientists and inventors. Some suggestions are:

Marie Curie
James Dewar
Nikola Tesla
Georg Ohm
Peter Mitchell (1978 Nobel Prize)
James Fourier
Michael Faraday
Alfred Kastler (1966 Nobel Prize)
Heinrich Hertz
Thomas Edison
Joseph Henry
Leon Foucault
Alessandro Volta
Benjamin Thomson (Count Rumford)
James Watt
Humphry Davy
James P. Joule
Lise Meitner
Albert Einstein

#2 SECRET WEAPON BURNS INVADERS

Whether or not Archimedes did set fire to ships' sails with sunlight has been subject for a controversy in the "letters" column of Science News (summer issues, 1978). One of the letters supporting the feasibility of this story appeared on July 15, 1978:

> ". . . I once saw a demonstration where 30 plane mirrors reflecting sunlight to the same area of a wood plank easily set it on fire. If the sun's image is spread over one-half degree (about .009 radians) then a one-square-meter mirror would spread its reflected energy over $9^2 = 81$ square meters at a distance of one kilometer. If the defenders of Syracuse had a battery of 30 x 81 = 2,430 such mirrors on their walls, aimed with the signal mirror method, they could have equaled the wood plank demonstration.

Even if Archimedes could have come up with only 600 mirrors and a burning distance of half a kilometer, he should have been able to convince the Romans to keep their distance. Surely there could have been 600 families of Syracuse that could afford a large polished mirror. When it was not in use defending the city, it would make a fine addition to the hallway."

Robert W. Davis
Gainesville, FL

#20 FROM HUMAN FOOD TO MACHINE FUEL

Brasilia, Brazil, 1995

The following suggestions for discussion questions (appropriate in various social science classes) were contributed by Sr. Margaret Brockamp of Kuemper High School, Carroll, Iowa.

Objective:

An examination of how this policy of alcohol production from sugar cane and tapioca affects a country like Brazil where extreme poverty exists.

Note the Paradox:

Brazil is one of the largest and potentially richest countries in the world, yet a great amount of deprivation and poverty exists. In recent years Brazil has experienced significant growth and development of its human and physical resources.

What percent of Brazilians rely on sugar cane and tapioca as their staple diet?

How could their diet be changed? Would it be difficult to do so?

Discuss some of the community problems which would be raised for the building of alcohol-distilling plants in a less developed country such as Brazil.

Specify the conditions which would need to be present to extend these plants.

Research the extent to which Brazil has developed ethanol and whether or not this knowledge has spread to other Latin American countries.

If widespread use of ethanol were developed, what would be the results for developing societies and for the world in general?

#21 WILL COAL BECOME NEXT POWER BASE

This imaginative article, forecasting a possible response to re-discovery of coal, parallels the nuclear debate in many respects. Unlike most science fiction, it postulates no new technology but a reinvention of an older one. This is perhaps analogous to the situation with solar use of heat, especially in bermed or underground buildings, and in greenhouses.

Dr. Frisch has been intimately involved with nuclear physics and the development of its potential and problems. He obtained his Ph.D. at the University of Vienna in 1926. He taught in Berlin and Hamburg, and later worked in Bohr's laboratory in Copenhagen. When his aunt, Lise Meitner, fled Germany and evolved the suggestion that uranium was undergoing fission under neutron bombardment, he collaborated in the paper that resulted. Dr. Frisch has since earned a reputation as a popular science writer. Along with his permission to reprint this imaginative and humorous article, Professor Frisch wrote, "I hope Iowans are so proud of their coal that they remember it is a valuable chemical, too valuable for burning!"

Some suggested questions for student discussion or reports:

1. What date would <u>you</u> assign to this article? Why? (It was arbitrarily chosen by this author, not by Dr. Frisch.)

2. How many generations away is 4,000 A.D.? (Good place to discuss length between generations and subsequent "doubling" time . . . . It varies with age of the woman at time of childbearing. See charts attached to GROWING TIME. A practical "mean" of 25 years is often suggested, but so is the statistic that more than half of all U.S. women complete their families before age 26.)

3. Could people really "forget" all about coal in as little as 2,000 years? Explain your answer. If "no," why not? If "yes," what conditions do you foresee that would lead to abandonment of this resource?

4. What time-frame did Dr. Frisch himself consider in writing this report? (Clue is in last paragraph.)

5. In giving permission for this article to be reprinted, Dr. Frisch wrote, "I hope Iowans are so proud of their coal that they remember it is a valuable chemical, too valuable for burning!" What does he mean?

   a. What is a "chemical"?
   b. What are the uses of coal?
   c. Which of these uses is most important to you? to your school? to your future job or your parents' jobs?
   d. Which uses of coal could you live without?

6. What are the similarities in the considerations Dr. Frisch reports regarding use of coal and those which have slowed the growth of the nuclear power industry? What are the differences in the trade-offs these two fuel sources require?

7. What other power sources that we now use are likely to be forgotten by 4,000 A.D.?

8. Make a guess of your own on either what the "new" or the "established" power sources may be at some future time. Choose your time frame.
   a. What are its disadvantages/advantages?
   b. What does it cost?
   c. How does it affect peoples' lives?

   Describe in some detail the power source itself. Description may be in essay form, a poem, drama, a picture, a collage, a model, a demonstration, or any other media the teacher is willing to accept.

9. An alternative activity: Suter's "Utility" (included in this activity) is also an example of futuristic thinking as an art form. Some students may want to use it as an "end point" and discuss or write a sequence of events that led to this "break-through." Others may wish to comment on social and legal impacts of this kind of power system at the future time described by Suter. Still others may wish to consider "What's next?" after the time portrayed by Suter. What subsequent refinements in energy production would likely follow the scenario Suter imagines?